

4.0 TECHNICAL APPROACH

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4.0 TECHNICAL APPROACH

4.1

INTRODUCTION

The Corrective Action Permit requires implementation of Stabilization Measures to limit or minimize the spread of contamination. Specific permit requirements for the Stabilization Measures Work Plan for the existing Conveyance include a description of the stabilization action, a schedule for implementing these actions, and a monitoring program for measuring and reporting on the effectiveness of the actions. Since the stabilization actions are similar to closure activities for interim status units, the permit also requires that the Stabilization Measures Work Plan include all applicable requirements of 40 CFR 265.228 relating to closure of surface impoundments.

This section of the Work Plan describes methods to conduct stabilization activities within the existing Conveyance and provides a schedule of the activities. Methods proposed to manage wastes, including stormwaters and process waters, and procedures to be implemented to minimize pollution incidents are included in Section 5.0, titled Waste and Material Handling. Measures to monitor the effectiveness of the stabilization activity are described in Section 6.0, titled Stabilization Measures Quality Assurance Project Plan; Section 7, titled Environmental Sampling and Analysis Plan; and Section 8, titled Post-Stabilization Actions, where the Groundwater Monitoring Program is discussed.

This section includes the following:

- Stabilization Measure Objectives (Section 4.2)
- Selection of Stabilization Methods (Section 4.3)
- A summary of the Treatability Study (Section 4.4)
- A discussion of engineering parameters and their derivation (Section 4.5)
- Stabilization techniques for each zone and subzone (Section 4.6)
- A schedule of stabilization activities (Section 4.7)

STABILIZATION MEASURE OBJECTIVES

The objectives of the stabilization actions are to (1) limit or minimize the spread of contamination in accordance with the Corrective Action Permit, and (2) close the Conveyance as an interim status unit in accordance with the applicable requirements of 40 CFR 265.228. The applicable requirements to meet these objectives are defined by the following.

- Corrective Action Permit Stabilization Requirements.
- 40 CFR 265.228 Closure Requirements for Interim Status Surface Impoundments.

Guidance referred to in developing the stabilization measures includes the following:

- Guidance appended to the Corrective Action Permit.
- USEPA guidance documents applicable to closure of disposal surface impoundments as disposal units.

The applicable technical requirements of 40 CFR 265.228 are summarized below for impoundments closed as disposal facilities.

- Eliminate free liquids.
- Stabilize remaining wastes to support the final cover.
- Install a final cover designed to:
 - minimize liquid migration.
 - function with minimum maintenance.
 - promote drainage.
 - minimize erosion and abrasion.
 - accommodate settling and subsidence.
 - have a permeability less than or equal to the lowest permeable member in the unit, or in this case, the natural subsoils.
- Provide monitoring and maintenance of the final cover during the period of post-stabilization care.
- Prevent run-on or runoff from damaging the final cover.

USEPA guidance documents such as "Stabilization Technologies for RCRA Corrective Actions" (EPA, 1991) and "Final Covers on Hazardous Waste

Landfills and Surface Impoundments" (EPA, 1989) were reviewed in developing the stabilization technologies to be used in this action.

4.3

SELECTION OF STABILIZATION METHODS

The selection of stabilization methods was guided by the following general criteria.

- Ability to meet technical criteria for closure caps (40 CFR 265.228).
- Consistency with applicable USEPA guidance documents.
- Compatibility of construction and operation of the technology with refinery operations.
- Acceptance of the process in similar applications.
- Effectiveness of the process in achieving design objectives.
- Constructability.
- Cost.
- Operation and maintenance.

Based on these selection criteria, the following stabilization activities were developed.

- Reduction or control of free liquids in the Conveyance during stabilization activities.
- Consolidation of the majority of the soft sediments into the pH Basin and other areas of the existing Conveyance.
- Solidification or other forms of stabilization to provide structural support for the cap.
- Abandonment, decommissioning, or decontamination of materials, structures, debris, pipes, and culverts that are currently located within the Conveyance and that will not be removed or covered by a cap.
- Installation of low-permeability caps, which will serve in certain areas to convey storm water run-on and minimize the vertical migration of liquids through the caps into the soft sediment.
- Post-stabilization groundwater monitoring, inspection, and maintenance to assure and confirm the effectiveness of the stabilization activities.

Stabilization technologies proposed for the Middle Creek Abatement Project are described in the following sections.

4.3.1

Solidification

As required in 40 CFR 265.228(a)(2)(ii), wastes that remain beneath the final cover are to have bearing capacity sufficient to support the final cover. For materials which are present in the existing Conveyance but which may not provide sufficient inherent bearing capacity, solidification may be required.

Solidification was selected as the method to provide structural support for the final cover. The amount of material solidified will be based on the requirements for structural support. The solidification method will be optimized by the determination of the volume, weight, oil and grease, and moisture content of the soft sediments to be stabilized; adding a prescribed weight of Portland cement to the sediments; adjusting moisture as required; and mixing with backhoes, dozers, or other equipment to distribute the cement throughout the portions of the sediments or underlying sediments to be solidified. Consolidation and dewatering of the soft sediments will be performed as required to facilitate the solidification tasks.

A solidification treatability study was conducted using the soft sediment from the existing Conveyance to evaluate its solidification potential. During the study, soft sediment samples collected from the Conveyance were subjected to various additions of Portland cement, latex, organic carbon, sodium silicate, silica fume, and lime to determine whether the sediment strength could meet a 50 pounds per square inch (psi) strength goal, as described in "Stabilization Technologies for RCRA Corrective Actions" (EPA 625 6-91-026, August 1991) (EPA, 1991, page 37). This value was used only as a goal for the treatability study. Actual requirements indicate that an unconfined compressive strength of 15 pounds per square inch (psi) will satisfy structural requirements. Section 4.5.3 describes the structural requirements of the solidification. The results of the treatability study are described in greater detail in Section 4.4.

The treatability study indicated that the addition of 10 to 15 percent Type I Portland Cement (dry weight of cement per weight of sediment, or wt/wt) as a dry powder to the soft sediment is sufficient to provide a minimum unconfined compressive strength of 50 psi (7-day cure time) using a modified version of ASTM D1633-84. Compressive strength increased over time, and samples tested after a 30-day cure time were an average of 74 percent higher than the 7-day cure time compressive strengths. Compressive strengths were found to be proportional to the density of the soft sediment samples tested and inversely proportional to the oil and grease and moisture contents of the soft sediment.

Control of Liquids

Control of liquids is required for erosion and sedimentation control; for efficient excavation of material required to produce the desired slopes and elevations for optimizing the solidification process; and ultimately for separate storm and process waters after completion of the project.

Currently the Conveyance is used for the collection and transport of both process waters which include primary sludge solids from upstream units and the T-101 surge tank and storm waters. Completion of the Middle Creek Abatement Project (MCAP), of which stabilization activities are a part, will result in a segregation of process waters. All process wastewaters will be transported in a pipe.

The control of liquids during stabilization construction activities will be accomplished in a complex program that will be phased with the construction of the new Conveyance, and are described in detail in Section 5.3, Water Management During Construction. Control methods are described generally in the following paragraphs. The flow from outlets from the existing API separators within each zone under construction will be diverted around the zone as construction proceeds downstream. At project completion, these outlets will convey the oil-water separator flows to a process pipeline atop the final covered materials. Wastewaters formerly discharging to the Conveyance channel will be managed in a closed system.

Where possible, the sediments and other materials may be excavated as necessary to produce the desired elevations and slopes to consolidate the materials in the pH Basin area of the Conveyance. These consolidated sediments would be dewatered as required to stabilize the material to support the final cap. The result will be a more uniform moisture content in the soft sediment and increased compressive strength.

Temporary dams will be constructed at convenient points upstream and downstream of each construction area to divert flow around the particular Stabilization Zone being excavated. Well points will be installed, as needed, to reduce groundwater infiltration during construction. Water pumped from the well points will be conveyed downstream of the Closure Zone.

Pump tests were conducted in a previous investigation to establish the drawdown characteristics of the saturated zone at the site. The resulting transmissivity and storage coefficient are presented in Table 2-2. The data shown on Table 2-2 indicate that the transmissivity in the area is moderate to moderately low. This data and information on the groundwater flow gradient (Drawing 1-0-5A/25053A, Volume 2) will be used to determine the location

of the dewatering wells during construction. The only operational problem anticipated during the dewatering process is pump failure. Standby pumps will be available for installation under such circumstances.

Steel sheet piles will be installed parallel to the new channel to minimize surface water and groundwater flow into the construction area. Similarly, sheet piling will be installed around the pH Basin to minimize surface water and groundwater flow into the soft sediment and contaminated debris consolidation area. Steel sheet piles are described as a containment technology in "Stabilization Technologies for RCRA Corrective Actions" (EPA, 1991) as a short-term, immediate measure to enhance recovery or containment, and are used for construction or excavation dewatering purposes. These piles form a thin, low-permeability barrier to groundwater flow, and during construction, will extend above grade to divert surface water away from the Conveyance.

4.3.3 Excavation Methods

Stabilization of the old system and construction of the new system require excavation of materials from various locations to generate the required elevations and slopes for the installation of the appurtenances that comprise the new system. A number of excavation techniques may be used, including hydraulic dredging; backhoe, clamshell excavation, and dozer excavation; hydroblasting; and hand excavation and vacuuming.

Hydraulic dredging is one excavation technique that may be used in Zones B and D. This technique consists of a floating barge which uses either a revolving cutter head or auger to dislodge soil and sediments from the bottom of a body of water. A submersible pump, located adjacent to the cutting device, sucks up the dislodged sediments and pumps them to a designated discharge point. It is expected that this technique will be used to convey excess materials to the pH Basin for consolidation from Zones B and D. Use of this technique permits excavation without prior removal of water from the Conveyance.

Backhoe and or clamshell excavation will be used throughout the project for miscellaneous excavation. Truck transport shall be used to convey the cut materials to backfill locations. The excavation area will require removal of water prior to use of the backhoe. Clamshell excavation can be used to remove sediments below the water level.

Hydroblasting may be used in congested areas in which access for backhoes and trucks is restricted. This technique consists of a high-pressure, low-flow water source, which is delivered to the area requiring excavation. The

hydraulic force dislodges the material requiring removal and conveys it to desired backfill locations.

Hand excavation utilizes manual laborers equipped with shovels, picks, and wheel barrows. This technique may be required in areas that contain obstructions and are inaccessible to power excavation equipment.

Vacuuming consists of drawing a vacuum at the end of a suction pipe to withdraw materials to a container. The container is then moved and its contents discharged at a desired location.

4.3.4 Cover Design

4.3.4.1 General Cover Performance Criteria

As indicated in 40 CFR 265.228, a hazardous waste landfill cover should be designed and constructed to:

- Provide long-term minimization of the migration of liquids through the wastes left in-place.
- Promote drainage and minimize erosion and abrasion of the cover.
- Function with minimum maintenance.
- Accommodate settling and subsidence so that the cover's integrity is maintained.
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

Each of these aspects of the cover design is addressed below. The final cover was designed using guidance found in "Final Covers on Hazardous Waste Landfills and Surface Impoundments" (EPA 530-SW-89-047) (EPA, 1989).

4.3.4.2 Rationale for Selection

4.3.4.2.1 Concrete

Concrete was selected as the primary cover material in those portions of the Conveyance where large-quantity storm water flows must be managed and where the process wastewater pipe will be within the new Conveyance because concrete provides the best combination of design considerations. These

considerations include those listed above as well as those required for this specific design case. These include:

- Low permeability: The concrete cover will virtually eliminate percolation of run-on storm water into the materials beneath it. The permeability of concrete is expected to be in the range of 1×10^{-9} cm/sec.
- Durability: The concrete cover must be resistant to the erosion and abrasion of storm water run-on and will promote drainage.
- Strength: The concrete cover must withstand the hydrostatic pressure of the groundwater and must be capable of supporting the process pipeline, which will be installed inside the channel to segregate process waste from storm water.
- Certain portions of the concrete cover, such as areas where the process pipe is superimposed, will meet tank standards.

The design of the concrete channel will be in accordance with Environmental Engineering Concrete Structures (ACI 350R-89) guidelines to provide dense, impermeable concrete with high resistance to chemical attack. These guidelines include

- Monitoring the ratio of water to cement to reduce permeability.
- Providing adequate reinforcement to minimize shrinkage and resultant cracks.
- Designing construction joints for minimal movement.
- Providing water stops at construction joints.

Waterstops will be installed at each construction joint, and impermeable expansion joints will be installed, as required.

Traditionally, concrete structures require little maintenance. The durability of the concrete used for the new channel will be maximized by:

- Using adequate air entrainment to minimize freeze/thaw effects.
- Using good quality concrete to maximize resistance to chemical attack.

- Providing adequate cover for reinforcement to minimize the potential for corrosion.
- Using fittings and embedded items that do not corrode and damage the concrete.
- Filling and patching tie holes.
- Minimizing the potential for erosion of the concrete surface during curing.

4.3.4.2.2 Clay Cover System

For portions of the Conveyance which are not covered by concrete caps, a different cover type will be used. This cover type will be used to cover portions of the unit adjacent to the concrete capped Conveyance, portions of the existing Conveyance. This cover will be designed in accordance with EPA guidance entitled "Final Covers on Hazardous Waste Landfills and Surface Impoundments," (EPA 530-SW-89-047, July 1989) (EPA, 1989). The cover will be installed as a multi-layer system including:

- An armored surface component to minimize erosion and promote drainage from the cover.
- A drainage layer with a minimum hydraulic conductivity of 1×10^{-2} cm/sec that will effectively minimize water infiltration into the low-permeability layer and have a final slope of at least three percent after settlement.
- A low-permeability layer lying wholly below the frost zone that provides long-term minimization of infiltration into the underlying wastes. For interim-status facilities, the permeability of this member must be less than the permeability of the bottom layer of the unit. The permeability of the soils in the near-surface aquifer was estimated at 7×10^{-3} to 5×10^{-4} cm/sec in slug tests conducted in 1991. A goal of 1×10^{-5} cm/sec is established for the final cover. Based on the EPA guidance provided in Appendix 4.4.1, Figure 6, of the Final Covers Guidance Document (EPA, 1989), the regional average depth of frost penetration in the Philadelphia area is approximately 12 inches.

The cover systems selected for the Conveyance stabilization are dependent upon several zone-specific factors. In some instances, it is infeasible to install thick cover systems due to access and excavation restrictions, utility interferences, and the requirement of the end use of the covered channel to

handle large quantities of storm water. At other locations, factors that preclude the use of flexible membrane liners include inaccessibility, structural interferences to installation and field seaming, slope stability, and the requirement for high coefficient of friction between adjacent cover materials to avoid slippage. Compactive efforts required for natural, remolded clay (low-permeability) materials require a dense, compacted sub-base to support compactive forces to the clay soil. It may not be practical or feasible to sufficiently compact the sub-base as required at some locations in the field.

The systems specified herein address zone-specific concerns as well as provide a design that includes the components described in the EPA Final Covers guidance document (EPA, 1989). A basic cover system is described below, and variations of the system are included in the zone-specific stabilization procedures described in Section 4.6.

Impermeable Component

A geosynthetic clay liner (GCL) is the low-permeability component of the cover system in instances where a synthetic liner is used. A GCL is a flexible, polypropylene-bentonite sandwich providing a uniform layer of clay in a roll form. This material was selected because it affords ease of installation. The material provides a low-permeability barrier. It has a permeability coefficient of $<5 \times 10^{-10}$ cm/sec under 30 psi effective stress. It can accommodate mechanical penetrations through the material. It is thin (1/4-inch thick) and will allow for installation in access-limited areas. Sub-base compaction is less than that required for remolded natural clay because the material itself does not require field compaction. The fiber mat minimizes the erosive loss of the bentonite materials. The swelling capability of the bentonite clay allows for self sealing of cuts or tears of the material. Manufacturer's recommendation is for a 6-inch overlap. The manufacturer's specifications for a GCL are listed in Table 4-1.

To separate the GCL from the soft sediments and provide a clean working surface for installation personnel, prior to GCL placement, a 6-inch-thick layer of select soil containing no protrusions or rocks greater than 2 inches in diameter will be placed atop the stabilized sediment or backfill, and compacted to the extent that installation vehicles do not make ruts in the sub-base. To afford maximum protection of the GCL, a 6-inch-thick layer of select soil or geotextile fabric shall be placed atop the material.

Typically, the GCL will be used as the low-permeability member for the cover systems where concrete caps are not used. This includes areas adjacent to concrete capped areas where the concrete cap does not span the entire width of the existing Conveyance.

TABLE 4-1

TYPICAL GEOSYNTHETIC CLAY LINER MATERIAL SPECIFICATIONS (1)

	PROPERTY	TEST METHOD	UNITS	RESULT
BENTONITE PROPERTIES	Sodium			
	Montmorillonite	X-RAY	%	90 (TYP)
	Content	DIFFRACTION		
	Free Swell	USP-NF-XVII	ml	27
	Fluid Loss	API 13 B	ml	12
	Moisture Content (3)	ASTM D4643	%	20
ADHESIVE	Adhesion	Visual		Continuous Adhesion to Backing Material
PHYSICAL PROPERTIES	Clay Thickness	ASTM D1777	inches	0.17
	Composite Thickness	ASTM D1777	inches	0.2
	Wide Tensile Strength	ASTM D4595	PPI	60
	Grab Tensile	ASTM D4632	LB	90
	Bentonite Content (3)	Weigh	LB/SF	0.95
	@ 20 % moisture	12" x Roll Width		
HYDRAULIC PROPERTIES	Shear Resistance	ASTM D35.01.81.07 (draft)		
	Hydrated		DEG	>10
	Dry		DEG	>35
	Permeability			
	A) 2 psi Effective Stress	ASTM D5084	CM/S	5x10E-9
	B) 30 psi Effective Stress	ASTM D5084	CM/S	< 5 x 10E-10
	Permeability (2 psi Effective Stress)			
	C) 2" Overlapped (without the use of granular bentonite between the seams)	ASTM D5084	CM/S	< 5 x 10E-10
	D) Damaged GCL (3 each, 1" holes)	ASTM D5084	CM/S	< 5 x 10E-10
	E) After 3 Wet/Dry Cycles	ASTM D5084	CM/S	< 5 x 10E-10
	F) After 5 Freeze/Thaw Cycles	ASTM D5084	CM/S	< 5 x 10E-10

(1) Reference: James Clem Corporation Product Literature, May 1992.

TYP = TYPICAL

For areas with larger areal extent unobstructed by appurtenances and interferences and which permit thicker layers of materials, or which permit a greater compactive effort to be applied, the GCL may be replaced with a 2-foot-thick layer of remolded natural clay. The clay shall be placed on a prepared sub-base consisting of a 6-inch-thick layer of select soil containing no protrusions or rocks greater than 2 inches in diameter. The clay soil used for the low-permeability layer shall meet the following criteria:

- Have a coefficient of permeability of 1×10^{-5} cm/sec or less as determined in a laboratory utilizing either constant head (ASTM D2434 or similar) or falling head methods.
- Have a minimum clay soil content of at least 25 percent as classified by the U.S. Department of Agriculture (USDA) Grain Size Classification System.
- Contain no coarse fragments greater than 1/4-inch in diameter.
- Be free from organic materials (e.g., roots, wood, leaves, paper).

The clay used for the cap will be placed in 6-inch-thick lifts and compacted to a density that will attain the design permeability value, as determined by the Standard Proctor Test (ASTM D698). Water shall be added as necessary to attain the specified moisture range. This placement and compaction procedure shall be repeated to produce a uniform, minimum 24-inch-thick, compacted clay cap.

Drainage Component

The final cover design includes a drainage layer installed at selected locations for the removal of water that infiltrates from the protective layer. The drainage layer is designed to facilitate the rapid drainage of incident precipitation and run-on from the surface of the cap. Two materials have been selected for this purpose: a synthetic drainage net or 6 inches of coarse sand. The synthetic drainage net (geonet) is a high-profile, shaped mesh structure formed by intersecting strands of HDPE into an open-weave shape. The resulting net provides excellent planar water flow, is inert to biological and naturally occurring chemicals, and is resistant to ultraviolet light exposure. Additionally, the net is very thin (approximately 0.2 inch thick), a fact which permits a lower profile in the cover scheme. Based on manufacturer's literature (Tenax Corporation), the coefficient of permeability for flow transmitted through the geonet is 2×10^{-1} cm/sec. If a geonet is used, one manufactured with a permeable geotextile above and below the mesh to prevent intrusion and clogging by the overlying material shall be used.

Alternately, a 6-inch layer of coarse sand will be utilized. The sand used will be no greater than 3/8 inch in diameter, and classified as SP in the Unified Soil Classification System (described as "gravelly sands or poorly graded sands"). The sand will be free from organic material and contain no debris that could damage the underlying low-permeability member, or fines that might lessen the permeability of the member. The sand will possess a minimum coefficient of permeability of 1×10^{-2} . A permeable geotextile will be placed atop the sand layer to prevent intrusion and clogging by the overlying material. If used atop a remolded, natural clay, low-permeability member, an additional permeable geotextile will be placed between the clay and the sand.

Where drainage layers are used in the clay cap system, they will be constructed with a minimum 3 percent slope and allow collected water to freely drain from the cover.

Protective Layer

The EPA guidance document "Final Covers on Hazardous Waste Landfills and Surface Impoundments" (EPA, 1989) recommends placement of an erosion-impeding material. Because of the industrial location of the project and safety considerations, a vegetative growth layer is not practical. Therefore, a gravel protective layer is used. This material is selected because it prevents deterioration of the cap due to wind, heavy rain, temperature extremes, and erosion resulting from runoff. This material will also promote surface drainage of runoff and incident precipitation. The material selected shall be hard, tough, durable, uncoated, inert particles reasonably free from clay, silt, vegetation, or other deleterious substances. Such substances as chert, gypsum, iron sulfide, amorphous silica, and iron oxide are considered deleterious.

Protective layer materials for covering cap systems used for lining storm water channels shall meet the requirements of PENNDOT specifications Section 850 - Rock Lining, NCSA Size Number R-3 (Commonwealth of Pennsylvania, 1990). Materials used for covering other cap systems shall meet the requirements of PENNDOT Specifications Section 703.2 Coarse Aggregate, Type C, AASHTO Number 57.

Select fill (earth, free from organic materials and angular pieces greater than 2 inches in diameter) will be used beneath the protective layer material. A permeable geotextile will be installed between the select fill and the protective layer.

4.3.4.3 Cover Design Summary

The minimum specifications of the materials to be used in the cap system are summarized in Table 4-2. The specific cap systems proposed for the conveyance stabilization are further described in Section 4.6.

4.3.5 Decontamination of Structures

Structures consist of equipment within the existing earthen Conveyance and are classified as hazardous waste debris. This category includes pipes, culverts, foundation works, sheet piling, ladders, and stairs. The options for handling and management of these materials include (1) leaving in place if it will not interfere with construction of the new channel or cap and will be covered with the cap, (2) dismantling and placement within an area that will be capped, (3) dismantling and disposal off site as hazardous waste, and/or (4) decontaminating according to the techniques described in 40 CFR 268.45 titled "Treatment Standards for Hazardous Waste Debris." The last option allows the debris to be classified as nonhazardous.

The decontamination techniques anticipated (if this option is selected) include abrasive blasting, acid washing, scarification and grinding, spalling, and water washing and spraying. The exact technique will be chosen based on factors including the type of equipment, location of the equipment, accessibility of contamination, type of contamination, and the ultimate disposition of the equipment.

4.3.6 Performance Criteria Attainment

The performance criteria will be attained through the use of the stabilization measures described above. The improvements realized through the stabilization measures include the following:

4.3.6.1 Minimization of Infiltration and Prevention of Bathtub Effect

Concrete and clay materials used for capping the existing Conveyance shall provide a minimization of infiltration of liquids, while preventing a "bathtub effect" which could result if the bottom liner is less permeable than the cap. The low-permeability of the materials used for the cap (1×10^{-9} cm/sec for concrete, $< 1 \times 10^{-7}$ cm/sec for geosynthetic clay materials, 1×10^{-5} for natural clay) will be less than the permeability of the soils beneath the Conveyance (7×10^{-3} to 5×10^{-4} cm/sec as measured during slug tests conducted at four wells in the shallow groundwater system for the Class III Permit Modification conducted in 1991).

TABLE 4-2
MINIMUM COVER MATERIAL SPECIFICATIONS

ITEM	MATERIAL	MATERIAL SPECIFICATION	PERMEABILITY, cm/sec	INSTALLATION SPECIFICATION
Impermeable Member	Concrete	See Table 6-3.	$< 1 \times 10^{-9}$	See Table 6-3
	Geosynthetic Clay Liner	See Table 4-1.	$< \text{or} = 1 \times 10^{-7}$	Minimum six-inch joint overlap in accordance with manufacturer's recommendations placed on smooth, compacted surface
	Remolded Natural Clay	Have a minimum clay soil content of at least 25% as classified using US Department of Agriculture (USDA) Grain Size Classification System. No coarse fragments greater than 1/4 inch in diameter. Free from organic material.	$< \text{or} = 1 \times 10^{-5}$	Placed in six-inch lifts to a 24-inch thickness
Drainage Layer	Gravelly Sandy Soil	Unified Soil Classification (USC) SP - poorly graded sands, gravelly sands, little or no fines. Free from organic material.	$> 1 \times 10^{-2}$	Minimum six-inch-thick layer applied in one lift
	Geonet	Performance equivalent to soil, hydraulic transmissivity $> \text{or} = 1 \times 10^{-5}$ sq m/sec.		In accordance with the manufacturer's recommendations
Protective Layer		Capable of remaining in place and minimizing erosion of itself and the underlying soil component.		
	Coarse Aggregate	PENNDOT Specification 703.2 Type C, AASHTO No. 3 or 5 or equivalent.	NA	Minimum six-inch-thick layer applied in one lift
	Rock Lining (mixed gravel)	PENNDOT Specification 850, size R-3 or equivalent	NA	Minimum 12-inch-thick layer applied in one lift
Soil Particle Filter	Geotextile	PENNDOT Specification 735, Class 2 Type B.	$> 1 \times 10^{-2}$	In accordance with the manufacturer's recommendations
Select Fill	Soil	No coarse fragments greater than 2 inches in diameter. Free from organic debris; soil-like, compactable.	NA	

The new process wastewater and storm water systems are designed to minimize infiltration into the soft sediments remaining in the channel. The capped channel will not receive any dry weather flow. All process waters will discharge directly into the process wastewater pipeline and be conveyed to the pretreatment system. Storm waters in the new Conveyance will flow in a new concrete-lined channel. Run-on and storm water atop the clay-capped portions of the channel will be discharged through the drainage layers into the sumps and concrete-lined portions of the new concrete channel via weep holes installed in the concrete structures, or collection ditches installed adjacent to the drainage zone.

4.3.6.2 Erosion Protection

The cap systems are designed to minimize erosion. Concrete capping materials used for channel linings shall be constructed at slopes designed to minimize high-velocity flow. To maintain a low velocity, the main concrete channel cap will be constructed at a slope between 0.32 and 0.46 percent.

Portions of the cap using clay materials as the low-permeability member shall be constructed with a protective layer of select soils, geotextile fabric, and gravel (for cap systems not within drainage channels) and geotextile fabric and riprap (for cap systems within drainage channels). Protective layer materials shall meet the requirements of PENNDOT Specifications Section 703.2, Type A Course Aggregate, which includes standards for soundness (using AASHTO-T161 test method), abrasion (PTM No. 622), and friable particles (AASHTO-T112); or for riprap lining in channels, PENNDOT Specifications Section 850, Rock Lining.

Geotextile fabrics shall be used to separate differently graded materials, such as soil and gravels. The geotextile is designed to be permeable to water while preventing soils from being washed away.

4.3.6.3 Freeze-Thaw Effects

According to the EPA guidance, the average depth of frost penetration in the Philadelphia area is about 12 inches. All covers will be designed to prevent cracking or loss of strength through freezing and thawing cycles. The concrete cover will be designed to accommodate thermal expansion and contraction. It will also minimize the impact of freeze/thaw cycles on the solidified material. Therefore, there should be no significant effects. The geosynthetic clay or compacted clay cap will be covered with non-frost-susceptible soil, freely draining with a minimum of 18 inches of cover material. Proper precautions will be taken to schedule construction so that clay cap will not be installed during extended periods of sub-freezing temperatures.

4.4 TREATABILITY STUDY SUMMARY

4.4.1 Introduction

A treatability study was carried out on soft sediment samples from the Sun Marcus Hook Refinery to determine the viability of solidification as a stabilization technology for the Middle Creek Abatement Project. This project involves construction of a new, segregated, stormwater and process water conveyance systems and includes closure of the existing, combined stormwater and process water systems (Middle Creek and Walkers Run). Engineering design for the new conveyance system uses the Middle Creek and Walker's Run beds as sites for construction of the new system. To accomplish this construction, soft sediments (sludge) in the beds will be (1) removed, (2) solidified and used as construction material, to support the concrete Conveyance serving as a cap, or (3) solidified and not used as construction material. A combination of all three of the above alternatives is also likely.

4.4.1.1 Stabilization/Solidification

The addition of cementitious binding agents accomplishes three major objectives: provides a solid with high structural integrity; microencapsulates and chemically binds metals and organics to minimize or eliminate waste migration from the solidified mass; and decreases permeability to reduce fluid flow through the solidified mass.

The overall objective of the bench-scale treatability study was to determine whether solidification and stabilization of the sludge at the Sun Marcus Hook Refinery was a feasible technology for use in the Middle Creek Abatement Project. Thus, the thrust of the treatability studies was to determine (1) whether cementitious/additive systems could achieve solidification and stabilization cost effectively (i.e., excessive cementitious loadings not required), (2) whether such systems could achieve compliance with potential regulatory criteria, and (3) whether such systems could be field-implemented.

Accordingly, TCLP (Toxicity Characteristic Leaching Procedure), permeability, and freeze-thaw data were acquired to provide baseline information on various stabilization systems rather than to demonstrate compliance of an optimized mix to specific performance criteria. Experiments relating to materials handling properties of the stabilized solids also provide baseline data relative to field implementation rather than defining optimized parameters so that a consistent product (a sludge/cement mix that yields consistently similar properties) can be delivered in the field.

Given the discussion above, the following specific tasks were performed in this study.

1. Collection of samples for treatability studies from various study areas of the existing Conveyance.
2. Determination of certain waste characteristics such as moisture, oil and grease content, and pH that could affect solidification.
3. Molecular profiling of the waste to delineate the gross composition of all oil and grease components, not just hazardous compounds.
4. Performance of screening solidification studies using various cement/additive systems and various cement loadings to assess the solidification potential of sludge samples. Unconfined compressive strength was used as the measurement for evaluating solidification.
5. Performance of TCLP, permeability, and freeze-thaw tests on selected solidified samples to acquire baseline performance data for solidified systems.
6. Performance of exploratory studies addressing the materials handling characteristics of stabilized sludges.

4.4.2 Sample Characterization

4.4.2.1 Sample Collection

Two sets of sludge samples were collected. The first six samples were collected on January 14 and 15, 1992, whereas refining at the second set of samples was collected on March 26, 1992. The first set was collected at three points along the length of Middle Creek and was intended to represent the potential variation in sludge characteristics at those points. Information concerning the field sampling and sample locations can be found in Section 3. The second set of samples was collected to obtain a "worst case" sample, and the sample sites were selected based upon previously acquired analytical data.

The sludge was collected using a sludge sampler and, where necessary, a hand auger. The maximum volume of the sludge sampler was just less than one quart, so that multiple samples had to be collected to fill a 1-gallon tin paint can. Five 1-gallon tin paint cans were filled at each sampling site. Sample containers were filled one at a time to minimize release of organic volatiles. Attempts were made to put a somewhat mixed sample in each container, by

collecting sludge from various depths within a shallow depth zone or within a deeper zone. In general, shallower sludge appeared less dense, and deeper sludge appeared more dense. Accordingly, "deep" and "shallow" samples were collected from sample locations D1 and B4. Defining a "dense" layer at sample location F1 proved impossible, so that only a shallow sample was obtained at that site. A deeper sample, however, was collected from the nearby sample location F2.

Only shallow samples were collected at sites D4, E3, and E4. Additional sample information is tabulated below.

Sample Name	Time Collected	Date Collected	Sample Depth (in feet)
D1S	14:40	1/14/92	1 to 3
D1D	15:15	1/14/92	3.5 to 7.5
B4S	10:20	1/15/92	1 to 3
B4D	10:00	1/15/92	3.5 to 8
F1S	14:00	1/15/92	1 to 5
F2D	15:00	1/15/92	5 to 10
D4S	08:30	3/26/92	0 to 3.5
E3S	09:40	3/26/92	0 to 2
E4S	10:35	3/26/92	0 to 2

4.4.2.2 Sample Compositing

All of the five 1-gallon cans from each sample site were emptied into a clean, 5-gallon plastic pail and thoroughly mixed at a low shear rate to avoid possible alteration of sludge emulsion characteristics. The less viscous samples were stirred with a variable-speed, hand-held paddle mixer. The denser, more viscous samples were mixed by hand using a two-handed mixing/stirring device. The composite samples were always re-homogenized prior to the removal of subsamples for any study.

4.4.2.3 Molecular Profiles of Composite Samples

All nine composite samples were analyzed by Thermal Extraction-GC-MS (SW846, Method 8275) in order to characterize the molecular composition of the semi-volatile organic waste fraction. The emphasis was not only to note the presence of hazardous semivolatile compounds but also to identify nonhazardous, semivolatile compounds which may form the large majority of

compounds comprising the oil and grease. An example molecular profile is shown in Appendix 4.1, Figures 1A.

In summary, the oil and grease fractions of the sludges primarily contain medium-molecular-weight (150 to 250 mass units), alkyl substituted, polynuclear aromatics (PNAs) and medium-to high-molecular-weight (250 to 450 mass units) naphthenes. Such compounds have very low aqueous solubilities and consequently would be expected to have low concentrations in leachability tests such as TCLP. Low-molecular-weight PNAs, such as naphthalene and methyl naphthalene, are present, however. These compounds have higher aqueous solubilities and consequently should be the primary semivolatile compounds leached from the sludge in TCLP or other leachability tests.

4.4.2.4 Characterization of Compositied Sludge Samples

Percent solids, percent oil and grease, bulk density, and pH for the nine composited sludge samples are shown in Appendix 4.2, Tables 1-A and 1-B. Oil and grease analyses were carried out using SW846 Methods 3550 and 9070, ultrasonic extraction followed by gravimetric determinations. Density determinations of the sludges simply involved weighing a known volume of sludge. As the sludges were all viscous liquids, no void spaces occurred in the filled volumes. The pH of the first sample set was measured using SW846 Method 9041, whereas the pH of the second sample set was measured during SW846 Method 9040.

Oil and grease contents of the samples measured are only moderately high, ranging from 1.6 percent to approximately 9.0 percent. Oil and grease contents in this range suggest that solidification should not be a problem. Because the sludges contain relatively high amounts of solids (44 to 78 percent) bulking agents or gelling agents to absorb excess water may not be necessary. Finally, since pHs range from 6.0 to 8.0, cement curing will likely not require pH control additives. Thus, bulk characterization parameters support solidification as a viable remedial process.

Characterization data have been transformed to standard scores (deviation from the mean divided by standard deviation), and the various parameters have been linearly correlated to one another in Appendix 4.2, Tables 11 and 12. The data transformation and correlations were performed by a commercially available statistics program called Einsight™ by Infometrix. Not surprisingly, bulk density is highly linearly correlated with percent solids and is inversely linearly correlated to percent oil and grease. Appendix 4.1, Figure 2, shows the linear relationship between bulk density and percent solids. (Note that Figure 2 is not based upon transformed data.)

Screening Solidification Studies

A series of screening studies was conducted to assess the solidification potential of the samples. Most of these screening studies were performed on the six samples comprising the first sample set (Appendix 4.2, Table 1-A). To conserve samples, different studies, particularly those involving additives, were performed on different samples. The studies consisted primarily of adding varying concentrations of Type I Portland Cement to selected sludge samples, as dry powder or slurry.

The first three studies, summarized in Appendix 4.2, Tables 2 to 10, relate to how the stabilization will be implemented in the field and whether the cement will be added dry or as a slurry. Study 4 included the addition of three additives (sodium silicate, activate carbon, and latex) and is summarized in Appendix 4.2, Tables 13 and 14. Sodium silicate was used both to "bind" excess water and to possibly precipitate metals as silicate salts to reduce their leaching potential. Latex was used both to reduce permeability by filling microfractures which form during curing and to possibly absorb some of the hydrocarbon compounds. Activated carbon was used to adsorb some of the more volatile organic compounds. Silica fume was added in Study 5 and summarized in Appendix 4.2, Table 15. Silica fume was used to improve acid resistance to the solid and thereby increase durability. Study 6, summarized in Appendix 4.2, Table 16, used lime to counteract possible retarding effects of the oil and grease.

The Type I Portland cement used was from Lone Star Industries and meets ASTM specifications for both Type I and Type II cements. Of significance is the fact that the cement is a moderate sulfate resistant cement by virtue of a C_3A (tricalcium aluminate) content of 6.48%.

For screening studies of this type, as well as for sample conservation reasons, a modified version of ASTM D1633-84 (Compressive Strength of Molded Soil-Cement Cylinders) was used. In this test, the cemented soils are placed in 2-inch by 2-inch cylindrical PVC tube containers for curing and setting. The containers are capped with PVC lids to eliminate water evaporation from the sample and to reduce air diffusion into the sample. Curing occurred at $75^{\circ}\text{F} \pm 2^{\circ}\text{F}$ at a relative humidity of 50 to 70%. Unconfined compressive strength tests were performed using a Soiltest Versa-Loader with a 500, 2000, or 10,000 lb proving ring. Stabilized cylinders were compressed at a rate of 0.1"/minute, and compressive strengths were calculated from maximum load to failure.

Studies 1 to 6 above utilized a 7-day cure time. Study 7 utilized 29 and 30-day cure times. (Note: 28-day extended cure times are standard.

However, so many samples from a variety of different experiments had to be strength tested on the same day that it was not possible to measure the compressive strengths for the extended cure samples at 28 days. Accordingly, they were measured at 29 and 30 days.) Study 7 is summarized in Appendix 4.2, Table 17.

4.4.3.1 Results

The screening studies (Appendix 4.2, Tables 2 to 16) yielded a variety of pertinent results.

1. For the nine sludge samples, compressive strengths range from 6 psi (10 parts cement) to more than 2,300 psi (30 parts cement) for dry cement powder/sludge mixtures. With the exception of E4S, 10 to 15 parts dry Type I cement powder per 100 parts sludge (w/w) yielded 7-day compressive strengths of 50 psi or more.
2. For the six sludges in the first sample set (Appendix 4.2, Table 1-A), compressive strengths range from 12 psi (10 parts cement) to approximately 225 psi (30 parts cement) for cement in slurry form (water to cement ratio = 0.40, w/w) added to sludge. Generally, 15 to 20 parts cement (as a slurry) to 100 parts sludge (w/w) yielded 7-day compressive strengths of 50 psi or more.
3. Despite the fact that 7-day compressive strengths of 50 psi were achieved with moderate cement loadings, from a process design perspective, considerable variability exists in compressive strengths. For example, compressive strengths range (for 20 parts cement dry powder per 100 parts sludge, w/w) from 36.6 to 929 psi with a mean of 241.5 psi and a standard deviation of 271.2 psi. A strength of only 1.4 psi is required to support the final cap (see Section 4.5.3.2). Thus even the lowest compressive strength attained, 36.6 psi, is well in excess of the required minimal strength.
4. Compressive strength correlates well with sludge density (Appendix 4.2, Table 12). As sludge density is positively correlative with percent solids and inversely correlative with percent oil and grease, unconfined compressive strength, not surprisingly, also correlates positively with percent solids and inversely with percent oil and grease. Appendix 4.1, Figures 3, 4, and 5, graphically show relationships between unconfined compressive strength and sludge density, percent solids, and percent oil and grease. Note that although the correlation coefficients in Appendix 4.2, Table 12, are based upon first-order, linear relationships, Appendix 4.1, Figures 4 and 5, suggest that the relationships between

compressive strength and percent solids and percent oil and grease are higher order, non-linear relationships. Appendix 4.1, Figures 3, 4, and 5, are based upon 20 parts dry cement per 100 parts sludge, but similar curves may be constructed using data for other cement loadings.

5. Cement powder/sludge compressive strengths are greater than cement slurry/sludge compressive strengths. This is true even when cement loadings are converted to true percentages as shown below.

$$\% \text{ cement} = (\text{wt. cement} / \text{wt. cement} + \text{wt. sludge} + \text{wt. added water}) \times 100$$

6. Addition of liquid sodium silicate causes a general increase in compressive strength relative to cement mixtures without the silicate. This increase is particularly evident for B4S (Appendix 4.2, Table 13). The data for D1D (Appendix 4.2, Table 14) are more equivocal. The data for both samples, however, suggest that in regard to sodium silicate addition, an effective upper limit (point at which further addition of sodium silicate does not cause a significant increase in strength) was not reached in these experiments.
7. Addition of activated carbon appears to cause a slight strength increase relative to cement mixtures without the carbon. This effect appears greater in B4S (Appendix 4.2, Table 13) than in D1D (Appendix 4.2, Table 14).
8. Addition of activated carbon appears to cause an overall decrease in unconfined compressive strength relative to cement mixtures without Latex 2000. However, for both samples B4S and D1D, 1.0 to 2.0 percent latex relative to cement (w/w) caused an apparent increase in strength. Latex additions of 5.0 to 20.0 percent relative to cement (w/w) caused significant decreases in strength. Additional work is needed with Latex 2000 to verify the above observations.
9. Addition of silica fume causes an increase in unconfined compressive strength relative to cement mixtures without the silica fume (Appendix 4.2, Table 15). This strength increase occurs over the range of 5.0 to 20.0 percent weight percent silica fume relative to cement. At 50 percent silica fume relative to cement (w/w), the strength of D1S continued to increase while the strength of F2D decreased to a value almost 40 percent lower than the strength of F2D without silica fume. The reason for this decrease is not clear.

10. The addition of small amounts of lime (0.5 to 2.0 percent) appears to increase compressive strength (Appendix 4.2, Table 16). The data may indicate that the addition of more than 5 percent lime decreased compressive strength.
11. The treatability studies indicate that 29- and 30-day compressive strengths average 74 percent higher than 7-day compressive strengths (Appendix 4.2, Table 17). Considerable variability exists in the percent increase in strength numbers calculated in Appendix 4.2, Table 17, but the factors causing that variability have not been delineated in this study.

4.4.4

Baseline Permeability, TCLP, and Freeze-Thaw Data

Screening solidification studies demonstrated that sludge samples could easily be solidified by moderate additions of a Type I Portland cement. Additives such as liquid sodium silicate, silica fume, lime, and activated carbon further increased 7-day compressive strength at certain loadings. This section addresses other properties of solidified sludges: TCLP characteristics, freeze-thaw behavior, and permeabilities.

Three sludge samples with low, moderate, and high oil and grease contents were chosen for TCLP and permeability tests. These three sludges had similar solids content.

Sample	Oil and Grease (%)	Solids (%)
D1S	8.70	64.6
F2D	4.96	64.8
B4D	3.52	68.8

Two different sludge samples were chosen for freeze-thaw tests. F1S was selected because it had the highest water content of all the sludges. B4D was chosen because it had the largest quantity of sample remaining for use.

Sample	Oil and Grease (%)	Solids (%)
F1S	6.44	50.5
B4D	3.52	68.8

All five sludges were solidified using 20 parts Type I cement per 100 parts sludge. Additive concentrations (Latex 2000, silica fume, and activated carbon) were 20 percent additive by weight of cement (4 parts additive per 100 parts sludge). The solidified mixtures were placed in 2-inch by 2-inch, cylindrical PVC tube containers for curing and setting, as previously described.

Permeabilities were performed using ASTM D5084-90 (Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter). Freeze-thaw tests were performed using ASTM D560-89 (Freezing and Thawing Compacted Soil-Cement Mixtures). TCLP extractions were carried out in accordance with SW846 Method 1311 protocols. Oil and grease determinations of the leachates were carried out using a modified standard wastewater partition-gravimetric method. (Methylene chloride was the solvent instead of freon.) Metals analysis of the leachates were performed using SW846 (3015 for microwave assisted digestion of aqueous solutions) and EPA Methods for Chemical Analysis of Water and Wastes (200.7, 270.2, and 206.2).

4.4.4.1 Results

Unconfined compressive strength data are shown in Appendix 4.2, Table 18; permeability data in Appendix 4.2, Table 19; oil and grease TCLP data in Appendix 4.2, Table 20; and metals TCLP data in Appendix 4.2, Tables 21 to 24. The analytes selected for the analysis of the TCLP leachate were chosen based on evaluation of the as-received analytical results discussed in Section 3.

Interpretations of these data are given below.

1. As shown previously, sludges with low oil and grease content have higher unconfined compressive strengths than those with high oil and grease content. Thus, B4D forms the strongest solids, whereas D1S forms the weakest. Moisture contents are similar for these three samples.
2. Seven-day unconfined compressive strengths consistently exceeded 100 psi. The values in Appendix 4.2, Table 18, are higher than values reported in Appendix 4.2, Tables 2 to 7, for 20 parts cement per 100 parts sludge because all of the sludge samples had lost water due to evaporation in the laboratory. Such losses resulted from opening the sample container lids, homogenizing the samples, removing material for testing, etc., a number of times for each sample.

3. With the exception of samples treated with Latex 2000, permeabilities of all cement/additive mixtures were less than 1×10^{-7} cm/sec.
4. Oil and grease concentrations of the TCLP leachates (Appendix 4.2, Table 20) are all in the 2 to 7 ppm range. These leachate concentrations do not appear to reflect the initial oil and grease content of the sludge. Cement/activated carbon mixtures have oil and grease leachate concentrations 30 to 70 percent lower than other cement/additive combinations. The TCLP data for oil and grease indicate that the leachability of semivolatile organics is minor.
5. Although the sludge samples contain abundant concentrations of metals, TCLP leachate concentrations (Appendix 4.2, Tables 21 to 23) of metals from raw sludges are not high (typically less than 1.0 ppm), as shown by data from Blue Marsh Laboratories. Nonetheless, solidification using the various cement/additive loadings further reduced leachate concentrations, as indicated by zinc, lead, and chromium data. The type of additive did not appear to make a difference in resulting leachate concentrations, although this observation may reflect the fact that all leachate concentrations are near Practical Quantitation Limits (PQLs). Barium and copper concentrations appear higher in TCLP leachates of solidified sludges than for raw sludges, but well below applicable TC regulatory levels. The differences may reflect the fact that the analyses were performed by two different laboratories.
6. The freeze-thaw data (Appendix 4-2, Table 24) indicate that B4D exhibits little weight loss, irrespective of the cement/additive mixture. Conversely, F1S exhibits significant weight loss, irrespective of the cement/additive mixture. Interestingly, the silica fume-containing samples have the lowest weight loss for both B4D and F1S. F1S has both higher oil and grease and higher moisture content than B4D. Whether the oil and grease, the moisture, or a combination of both contributed to the poor freeze-thaw behavior of F1S is not known. However, freeze-thaw resistance is not a concern since all stabilized sediments are below the EPA recognized frost penetration depth.

4.4.5

Exploratory Materials Handling Studies

Previous sections of this Work Plan have demonstrated that sludges at Sun Marcus Hook can be solidified with moderate additions of Type I Portland cement, that the solid products have low permeabilities, that the solid products exhibit low leachability of metals and semivolatile organic compounds, and that good durability can be achieved with freeze-thaw tests.

This section of this Work Plan relates to how stabilization will actually be implemented in the field. The experiments described below address this activity.

At the time these bench-scale experiments were performed, field implementation plans called for stockpiling the sludge after removal from Middle Creek. As needed, the stockpiled sludge would be transported to an onsite pugmill, solidified, and used for construction purposes. Because the stockpiled sludge would dewater, both by gravity drainage and by evaporation, the handling characteristics of the dewatered, solidified sludge were necessary factors to be determined. Accordingly, the experiments described below entailed the simulation of stockpiled material with attendant dewatering and solidification of dewatered sludge. The experiments constituted a time series of sludge properties and solidified sludge properties as a function of degree of dewatering.

4.4.5.1 Experimental Procedure

Five sludge samples were used in these studies: B4D, B4S, D4S, F1S, and E4S. These samples spanned a range of oil and grease content (3.52 to 8.92 percent) and moisture content (31.2 to 56.1 percent). Two kilogram samples of each sludge were placed in a mound in 1-gallon buckets. The bottoms of the 1-gallon buckets were perforated with numerous holes to allow water drainage. A thin paper towel was placed in the bottom of each bucket over the holes to prevent sludge from flowing through the holes. The 1-gallon buckets were suspended in 5-gallon buckets so that water draining from the former would collect in the latter. The 5-gallon buckets were placed in a fume hood that was left on throughout the duration of the dewatering experiments. Considerable water evaporated from the sludge samples as a result of air flow through the fume hoods.

Every 24 hours a sample of dewatered sludge was solidified with the addition of 20 parts dry cement powder per 100 parts sludge. In conjunction with solidification, the density and moisture content of the sludge prior to cement addition, the density and moisture content of the cement/sludge admixture, and the density and moisture content of the solidified sludge (after 7 days curing) were also determined. The unconfined compressive strength of the solidified dewatered sludges was determined as well. Moisture, density, curing, and strength testing procedures were described earlier in the report.

4.4.5.2 Results

Data for the materials handling studies are presented in Appendix 4.2, Tables 25 to 29. In addition to moisture, density, and compressive strength

data mentioned above, textural descriptions of the sludge/cement mixtures are provided. The goal of the studies was to obtain a sludge/cement mixture that was moist, granular, easily compactable, and formed strong solids. Such a material would be easy to handle from a construction perspective.

Appendix 4.1, Figure 6, displays unconfined compressive strength as a function of moisture content for the five sludges. Two points are particularly noteworthy. First, maximum strength development for 20 parts cement addition per 100 parts sludge occurs at lower moisture content than in the starting sample for all sludges. Appendix 4.2, Table 30, shows the moisture content at the estimated point of maximum strength. This point is estimated from Appendix 4.1, Figure 6, and Appendix 4.2, Tables 25 to 29. The amount of water lost to achieve maximum strength is also shown in Appendix 4.2, Table 30. Although the data set is not very large, Appendix 4.1, Figure 8, suggests that the amount of water lost from a sludge to achieve maximum solidification strength is linearly dependent upon the original moisture content. The lower the water content of the original sludge, the less dewatering is required to obtain maximum strength. Secondly, "best" handling characteristics generally occurred with a loss of 10 to 20 percent water by weight of sludge. These data are also shown in Appendix 4.2, Table 30. Appendix 4.1, Figure 9 shows that the amount of water lost to achieve good handling characteristics after solidification is also positively correlated with original moisture content. The significance of Appendix 4.1, Figures 8 and 9, is that for any Sun Marcus Hook sludge, the amount of moisture that must be lost to achieve either maximum strength or good handling characteristics after solidification can be estimated.

Data in Appendix 4.2, Tables 25 to 29, combined with data in Appendix 4.2, Tables 1-A and 1-B, can be used to calculate percentage of oil and grease in the dewatered sludges. The major assumption in such calculations was that no oil and grease was lost due to evaporation. This is a good assumption, given the high-molecular-weight nature of the oil and grease and is corroborated by the following data.

Sample	% Moisture in "Dry" Sludge	% Oil and Grease in "Dry" Sludge	% Oil and Grease in "Dry" Sludge (Dry Wt. Basis)	Original Oil and Grease (Dry Wt. Basis)	% Recovery
B4S	3.40	5.8	6.2	6.2	100
F1S	8.02	12.6	13.7	12.8	107

By using data in Appendix 4.2, Tables 1-A, 1-B, 25 to 29, and calculated oil and grease contents for all dewatered sludges, Appendix 4.1, Figure 7, was

constructed. The data points in Appendix 4.1, Figure 7, indicate the compressive strength for solidified sludge samples and dewatered sludge samples each having a specific moisture and oil and grease content. The compressive strengths have been contoured at intervals of 100 psi. A maximum strength line is drawn through the contour trend exhibiting highest compressive strength.

Appendix 4.1, Figure 7, allows the estimation of compressive strengths from oil and grease contents of Sun Marcus Hook sludges. It can be used as well to indicate the moisture content and oil and grease content required to yield a certain strength. In conjunction with Appendix 4.1, Figures 8 and 9, Appendix 4.1, Figure 7 represents preliminary data required to construct a process design envelope (with respect to moisture and oil and grease) such that a solidified sludge with uniform and predictable properties (strength in this case) can be produced during field construction.

4.4.6

Conclusions

The following conclusions are the most important ones to be drawn from the data presented above.

1. Soft sediment sludge samples from the refining contain 44 to 78 percent solids and moderate amounts of oil and grease (1.5 to 9.0 percent). The oil and grease primarily contain medium molecular weight alkyl substituted polynuclear aromatic hydrocarbons and 3 to 5 ring cycloalkanes.
2. The sludges can be solidified with moderate amounts of cement. Generally, 10 to 15 parts dry Type I/Type II cement per 100 parts sludge is sufficient to yield a 7-day compressive strength of 50 psi. Similarly, 15 to 20 parts cement (added as a slurry) per 100 parts sludge will generally give a 7-day compressive strength of 50 psi.
3. Compressive strengths are highly correlative with density and inversely correlative with moisture content and oil and grease content. Thus, the higher the oil and grease content and the higher the moisture content, the lower the compressive strength for a given cement loading.
4. Addition of small amounts of reagents such as liquid sodium silicate, silica fume, lime, and activated carbon increases compressive strength. Latex 2000 causes an overall decrease in unconfined compressive strength.

5. Sludges solidified with 20 parts dry cement powder per 100 parts sludge (w/w) have permeabilities less than 1×10^{-7} cm/sec range. Such permeabilities are also found when additives such as soluble sodium silicate, silica fume, and activated carbon are used.
6. Oil and grease contents of TCLP leachates of solidified sludges are 2 to 7 ppm. Individual metal concentrations of TCLP leachates are typically less than 300 ppb and are often near Practical Quantitation Limits (PQLs).
7. Limited freeze-thaw data are equivocal. One sample (B4D) exhibited little weight loss, whereas one sample (F1S) exhibited substantial weight loss. The factors governing freeze-thaw behavior of solidified sludges were not delineated in this study. However freeze-thaw is not a concern because the solidified material is below the EPA recognized frost penetration depth.
8. Dewatering studies indicated that for 20 parts dry cement per 100 parts sludge, maximum compressive strength generally occurred with water loss of 5 to 15 percent by weight of sludge. The lower the original water content of the sludge, the less dewatering is required for maximum strength development.
9. Good construction materials handling properties of solidified sludges can be obtained with additional dewatering. Generally, 10 to 20 percent (by weight of sludge) loss of water will yield solidified sludges that are moist to semi-dry, granular, soil-like, and easily compactable. The lower the original water content of the sludge, the less dewatering is required to achieve good, workable, solidified sludges.
10. Using 20 parts dry cement per 100 parts sludge (w/w), compressive strength can be contoured as a function of moisture content and oil and grease content. Such maps can form a basis for constructing process design envelopes so that solidified sludges with uniform and predictable properties can be produced.

All of the conclusions presented above indicate that solidification is a very viable technology for the Middle Creek Abatement Project. Strong, low permeability solids with minimal leachability of metals and semivolatile organics can be formed. When the original sludge is dewatered, solids with excellent construction handling characteristics can be produced.

4.5 ENGINEERING PARAMETERS

The design of the new Conveyance system was performed using standard engineering practices. This section provides the basis for the design for each major component. Pertinent calculations included in the Appendices are referenced as applicable.

4.5.1 Storm Water Conveyance

4.5.1.1 Design Concept

The existing Middle Creek Conveyance will be replaced by an open, concrete-lined channel to convey noncontaminated storm water that drains from the refinery. This concrete Conveyance will also serve as secondary containment for the enclosed east process wastewater conveyance and receive runoff from the cap.

The open conveyance will terminate just east of Blueball Avenue in a new storm water sump equipped with two electrically driven, 500-gpm pumps that will be used to transfer water, accumulated during small storms, directly to the treatment system for ultimate discharge to DELCORA. Two 42,650 gpm diesel-driven pumps are also provided for use during heavy storm events to transfer water to Tank T-101 for storage until it can be processed through the treatment system.

Under normal conditions, stormwater in T-101 will be transferred to the 15 Plant Separator. Depending on the chemical composition of the T-101 contents, the stormwater can be transferred to DELCORA or directly to the River. Additionally the capability exists to pump the T-101 contents to the process wastewater surge tanks.

Drawings 1-0-5A/15008A through 15019A (Volume 2) indicate the manner in which the runoff will be conducted to the open channel from capped areas after the existing Conveyance has been covered. Section 4.3.4 discusses cover design measures to be used to assure that precipitation or runoff does not accumulate on the cover.

4.5.1.2 Design Flow and Channel Capacity

Storm flows were calculated using the expected maximum intensity occurring during a 25-year storm. Figure 4.5.1.2-1 shows the cumulative maximum flows which can be expected in the storm water conveyance during a once in 25-year storm event. Figure 4.5.1.2-2 shows the profile of the east process water conveyance within the stormwater conveyance and the expected level of the stormwater at the maximum expected flow in relation to the process pipe and the top of the Conveyance ditch. The computer printout of the data used in determining these profiles is contained in Appendix 4.3. The flow from 153.7 acres is handled in the storm water conveyance.

4.5.1.3 Structural Design

The reinforced concrete channel was designed in accordance with ACI 350R-89, Alternate Design Method. This alternate design method is the Working Stress Design of ACI 318, Appendix A. ACI 350 was used to meet the serviceability requirements of the code. Splices in the structure conform to ACI 318. Five different wall heights were used for analysis to optimize construction costs. Design assumptions included a 400 per square foot (psf) surcharge load for future maintenance equipment, 4,000 psi concrete, and 60,000 psi rebar. Engineering calculations illustrating the design of the wall and bottom slab thickness, reinforcing steel requirements, and expansion/contraction/ construction joints and water stops are included in Appendix 4.4. Drawings 1-0-5A/12020A, through 1/12028A and 12040A through 12048A (see Volume 2) illustrate the layout of the channel and details of the reinforcing layouts, joints, and concrete thickness.

4.5.1.4 Conveyance Foundations and Soil Pressures

The majority of the soil borings (B-37-1 through B-37-19), see Appendix 2.1 along the Conveyance trench indicate that the Upper Stratum of soil is type "F, Loose Fill" (see Appendix 4.4, Appendix Page A), generally underlain by type "F, Dense Fill". Strata "F, Loose Fill" was used in the design calculations using the "at rest" earth pressure for the soil and the active earth pressure coefficient for the surcharge loading. The properties of the soil types encountered in the borings are summarized in Appendix 4.4, Appendix page A.

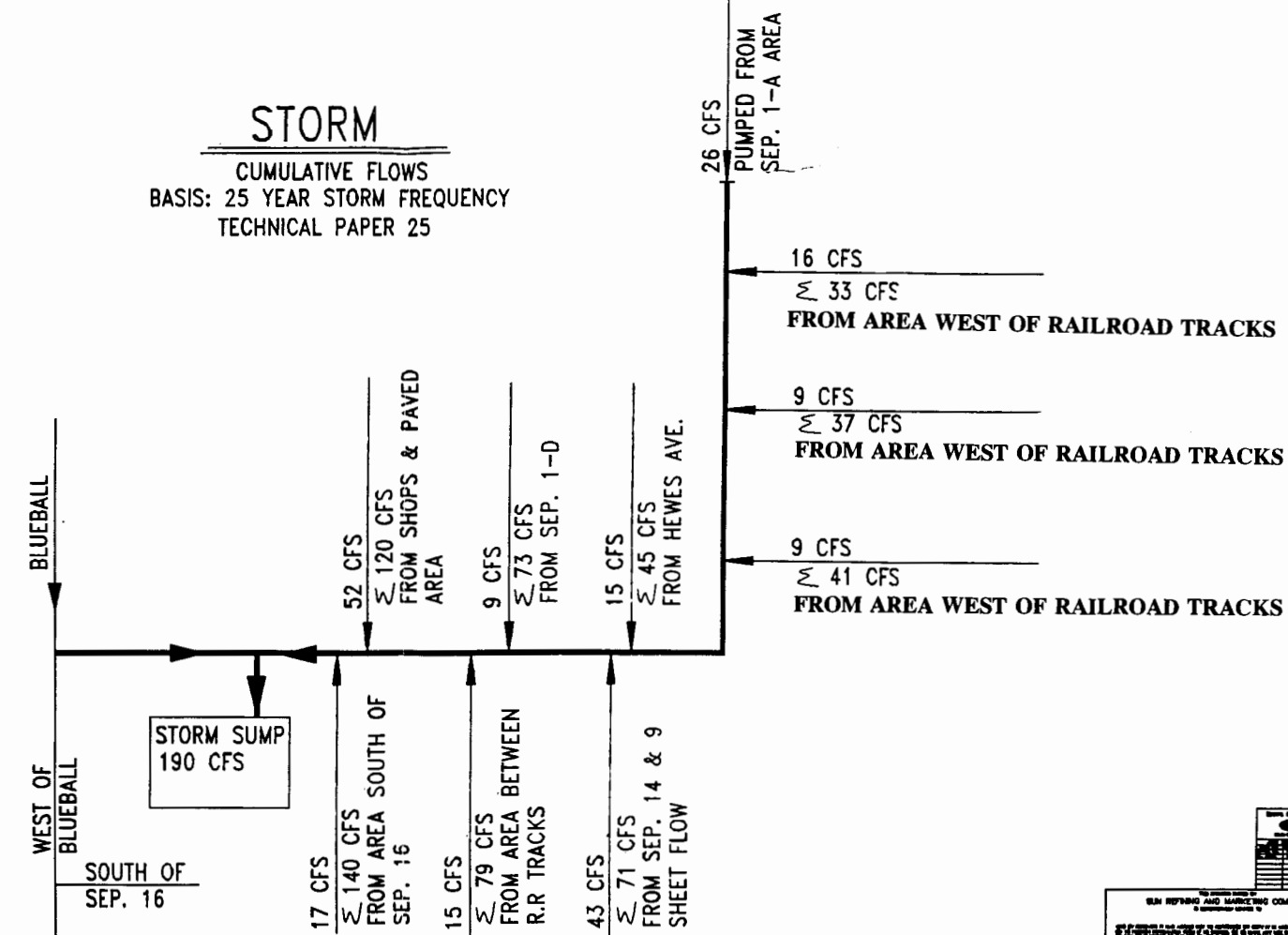


FIGURE 4.5.1.2.-1

PREPARED BY SUN REFINING AND MARKETING COMPANY IN CONNECTION WITH SUN REFINING AND MARKETING COMPANY MARQUIS HOOK REFINERY MARQUIS HOOK, PA.	
STORM SUMP CUMULATIVE FLOWS	
PLANT MARQUIS HOOK REFINERY MARQUIS HOOK, PA.	SHEET NO. SK-0086

4.5.2 Process Water Conveyance

4.5.2.1 Design Concept

The new process wastewater system for the east process area will consist of a closed, carbon steel pipe, gravity-flow system that starts at the inlet box of the 10 Plant separator and runs within the central storm water conveyance system, terminating in a covered sump (east process wastewater sump). The system will handle process wastewaters from areas currently served by the 10 Plant separator, the 12 Plant separator, the 16 Plant separator, the 1-C and 1-F separators, and waters from W-12 Tank and the ethylene complex. Contaminated storm waters from the east process area will also be handled in this system.

The East Process Water Sump will have two chambers. The smaller chamber will handle dry-weather flows, and the larger chamber will handle heavy flows during storm events. The two chambers are separated by an under over baffle that will provide for oil-water separation in the dry-weather chamber. Oil skimmed from the water surface will be pumped directly to a recovered oil tank.

The existing west process wastewater system will remain, except that the existing flow to the 15 Plant separator will be diverted to a new sump. Flows to the new West Process Water Sump originate in the 15 Plant and 17 Plant. The west process sump will also have two chambers, the smaller of which will handle dry-weather flows and a larger chamber to handle heavy flows during storm events.

4.5.2.2 Design Flow and Capacity

Water in the dry-weather chamber of the East Process Water Sump will be transferred to the separator by two 2,550-gpm, electrically driven pumps. During heavy storm events, water in the wet-weather chamber will be transferred by two 46,000-gpm, diesel engine-driven pumps to the two new 7.5-million-gallon, process wastewater surge tanks to be held until the water can be processed. Stormwater from 163.5 acres is delivered to the east process water system.

Two 2,550 gpm electrical pumps will be installed to transfer the west process water, dry weather flow directly to the 15 Plant separator. During heavy storm events, water in the wet-weather chamber will be transferred by two 32,300-gpm, diesel-engine-driven pumps to the two process wastewater surge tanks, where it will be held until the water can be processed. Stormwater from 63.2 acres is handled in the west process water system.

4.5.2.3 Structural Design

The design of the process pipeline was analyzed for maximum stress using the requirements of the ASME Piping Code B31.3 (1987). Four expansion joints in the pipeline are designed to allow for thermal expansion and contraction of the welded carbon steel pipe. A computer stress analysis program, CAESAR II, was used to determine the maximum stresses along the pipeline at varying conditions. The pipeline was broken into two segments for analysis purposes, the section from Post Road to Middle Creek Road, and the section from Middle Creek Road to the pipeline terminus at the East Process Sump near Blueball Avenue. Four environmental conditions were analyzed for each segment, including:

- temperature = -10 F
pressure = 1 psig
line empty
- temperature = 110 F
pressure = 1 psig
line empty
- temperature = 80 F
pressure = 1 psig
line full
- temperature = 80 F
pressure = 1 psig
line empty
conveyance ditch full

The results of the pipeline stress analysis, which are included in Appendix 4.5, indicate that stresses are within the values permitted by the ASME piping code.

4.5.3 Solidified Material

4.5.3.1 Design Concept

The backfill along the outside of the concrete conveyance channel will be designed to resist the forces of the concrete channel and provide support for the capping materials. The concrete channel walls were designed using "Strata F, Loose Fill," which is the soil classification for the poorest structural soils at the site. Therefore, any soils having strength characteristics greater than "Strata F, Loose Fill," will resist earth pressure. Compactive effort

typically required for roadway base and subbase construction will be more than adequate for this construction because the system is designed such that no vehicular access onto the capped materials will be permitted.

4.5.3.2 Strength Requirements

Calculations regarding solidified material strength requirements (see Appendix 4.6) indicate that the two requirements of the backfill can be attained by the addition of a stabilizing agent to produce a cohesive soil which has a resulting unconfined compressive strength of 200 PSF (1.4 psi). These calculations consider the effects of a saturated field condition whereby the fluid pressure is considered over the entire depth of the conveyance channel side walls (10 feet), and all backfill is submerged. The buoyant unit weight of the backfill is used in the calculations. A goal of 15 psi unconfined compression strength will be used to guide the stabilization of these materials, which is equivalent to a good, load bearing soil. Additionally, the addition of stabilization agents to the backfill adjacent to the concrete trench should be performed to remove free liquids from the material being backfilled to produce a cohesive, soil-like material. The stabilized backfill material shall be compacted to 90 percent of Modified Proctor Density (ASTM D1557).

4.5.4 Bid Documents

Pertinent elements of the bid document package developed for the stabilization measures for this project are described in this section, including Sections 4.5.4.1 Subcontract Terms, 4.5.4.2 Specifications, and 4.5.4.3 Drawings.

4.5.4.1 Subcontract Terms

The Subcontract Terms developed for this project detail the contractual obligations of the subcontractor, to which he must adhere throughout the duration of the project. Major items which are addressed include

- Scope of work
- Time of performance
- Subcontractor price
-
- Change of rates
-
- Payment and performance bonds
- Payment terms
- Insurance
- Communication/correspondence

- Material Safety Data Sheets
- Site maintenance and access
- Waste management and disposal
- Quality of work
- Project documentation

A copy of the subcontract terms is included in Appendix 4.10.

4.5.4.2 Specifications

Specifications were developed to detail the work to be performed as previously described in Section 4.3.6. A list identifying all of the specifications, including mechanical, piping, process, electrical, civil, and structural, are included in Appendix 4.7. The specifications which pertain to the stabilization activities include:

020-D-005	Specification for Vertical Mixed Flow Pumps for the Conveyance System
061-D-002	Specification for Earthwork
061-D-007	Specification for Cement Treatment of Soils
061-D-008	Specification for Culverts
061-D-011	Specification for Excavation and Backfill for Underground Pipe, Conduit, and Ducts
062-D-004	Specification for Concrete Construction
062-D-005	Specification for Concrete Testing and Inspection
083-D-001	Specification for Stabilization Measures
083-D-002	Specification for Waste Materials Management
130-D-001	Specification for Environmental Sampling, Analysis and Characterization for Interim Stabilization Measures

Complete copies of these specifications are included in Appendix 4.8.

4.5.4.3 Drawings

Drawings were developed during the design which present the areas to be remediated and define the sample locations, zones, and construction details. A list of all drawings is included in Appendix 4.9. Selected Civil, Structural, Piping, and Site Layout Drawings, included in Volume 2, present the remedial action in its entirety. The numbering system for the design drawings is coded as follows:

SUMMARY SHEET SUN DRAWING REGISTER

Drawing Series	Subject Description
061-C-XXX	Civil Standards
062-C-XXX	Civil Standards
02XXX	Piping
12XXX	Concrete and Sheetpile
14XXX	Underground Pipe
15XXX	Grading and Paving

4.5.4.4 Changes to Design Drawings

During performance of the work, the occurrence of unforeseen field conditions may require revision of the design. If that occurs, the following procedure will be used:

- 1) The Construction Supervisor will notify the Project Manager.
- 2) The Project Manager will direct the designers to make the changes.
- 3) The revisions will be reviewed by the Engineering and Environmental discipline leads.
- 4) The revisions will be reviewed by the Construction Supervisor.
- 5) The changes will be incorporated into the construction program through subcontract change orders.

4.6 STABILIZATION MEASURE DESCRIPTION

The stabilization measure will be accomplished as follows:

- The majority of soft sediments from Zones A, B, C, D, and E and primary sludge solids that have been conveyed, suspended in water, as the result of normal operations including cleaning of units that lead into the conveyance or received water and solids from units such as surge Tank T-101, will be consolidated into the pH Basin (Zone F on Figure 1-2) and into reaches of the existing Conveyance as required to produce the desired cross sections of the new channel. Some sediments will remain in place and be capped.

- Waste management, including process waters and storm waters, will be accomplished as described in Section 5.0.
- The soft sediments will be physically stabilized to the extent necessary to support a cover.
- Concrete caps will be installed over areas of the existing Conveyance where storm water run-on must be drained. These concrete covers will be used over much of the existing Conveyance. Process wastewater will be segregated from storm water and transported in a separate pipe.
- Areas of the existing Conveyance not closed by capping with concrete will be closed by capping the soft sediments with a low-permeability synthetic cover.
- Construction Quality Assurance will be provided as described in Section 6.0.
- Post-stabilization care, including monitoring, inspection, and maintenance, will be performed following completion of the stabilization operation (see Section 8.0).
- A Health and Safety Plan for construction activities is included in Section 9.0.

To facilitate a systematic approach to closure, the site has been subdivided into six stabilization zones and further subdivided into subzones, based on the method of capping implemented (see Section 4.6.2).

4.6.1 Site Preparation

Prior to commencing stabilization of the existing Conveyance, site preparation work is required. This includes facility relocation and pH Basin preparation.

4.6.1.1 Access Roads and Decontamination Stations

Prior to initiating construction activities in the pH Basin area, access roads will be installed. The general procedure will be to scarify and recompact existing soils or place borrow material as a sub-base where necessary. A geotextile layer will then be placed over the sub-base with an additional 6-inch aggregate on top to serve as the final surface.

A decontamination area will be constructed for decon of haul trucks and equipment entering or leaving contaminated zones within the pH basin area as well as other work areas. The pH Basin decontamination area will also serve as a "hot" work zone for additional demolition work. Basic construction will consist of subgrade preparation and placement of a geotextile protective layer with a final 60 mil HDPE or geocomposite liner. Wooden mats will be placed on the liner for protection from equipment and truck traffic. The areas will be surrounded by a run-on/runoff control berm. All water collected in these areas will be discharged to the existing Conveyance.

4.6.1.2 Facility Relocation

Relocation of existing facilities that encroach into the existing Conveyance is necessary to implement the proposed stabilization measures.

Relocation activities include the following:

- Removal and relocation of existing pH control system in the pH Basin (Zone F, Figure 1-2). Demolition will be accomplished by manually dismantling the steel structures and removal via a crane. Larger sections will be placed in the decontamination/demolition area and will be further dismantled. Dismantled materials will be managed in accordance with the procedures described in Sections 5.4 and 5.5.
- Dismantling and replacement or relocation of major conveyance system obstructions including utility and process pipe systems, pipe rack foundations, and rail lines. These materials will be managed as described above.

4.6.1.3 pH Basin Preparation

The pH Basin will be prepared to receive materials excavated to attain the required elevations and slopes at upstream locations during construction of the new channel as well as material from surge tank T-101. The preparation will include the following:

- Install sheet piling just south of the railroad bridge and east of the dam at the downstream end of the pH Basin, both extending across the width of the Conveyance, as shown on Drawing 1-0-5A/25069A. This will form the consolidation area boundaries at either end of the existing water course, and prevent upstream waters from entering the consolidation area.

- Stabilize sediments in the bottom of the pH Basin on the south side of the basin as required to provide a suitable subbase for the pipe installation described below.
- Install two 60-inch-diameter, corrugated metal pipes atop the solidified sediments on the bottom of the pH Basin, extending from the sheet pile at the railroad bridge to the existing overflow structure for Tank T101. Extend the two pipes from the T101 overflow structure to the sheet piling at the dam. This pipe will convey waters collected from the upstream side of the sheet pile wall at the railroad bridge to the pumps at the dam. Install an overflow weir in the T101 overflow structure to direct normal flows to the dam face pumps, and allow storm flows to overflow to Tank T101.
- Stabilize sediments existing in the consolidation area and use a portion of this material to construct berms around the outside limits of the consolidation area shown on Drawing 1-0-5A/25069A. Drainage from this area will be conveyed to the plant treatment system.
- Install dewatering system to remove liquids from the consolidation area and convey these liquids to the plant treatment system.

4.6.2

Stabilization Zones

Drawings 1-0-5A/14000A and 14001A (Volume 2) illustrate the zones established to facilitate stabilization of the Conveyance. The environmental conditions of the existing Conveyance vary over its length. In some locations, equipment access to the existing Conveyance is virtually impossible. The stabilization method therefore must be adjusted for the conditions encountered in each zone. The zone concept provides a systematic approach to closure and stabilization measures while maintaining refinery operations during construction. This approach will accommodate the continued transport and treatment of process wastewater and storm water while the cover caps are installed, the process wastewater segregated, and the wastewater pipe is built. Upon completion of construction within a zone, process wastewater and storm water will be conveyed in the new system.

The construction work within the stabilization zones will be consistent with regulatory requirements for closure and the stabilization requirements in the Corrective Action Permit. Solidification will be provided to the extent necessary to provide stability, strength, and support for the new system

structure and the cap. The following subsections provide zone-specific methodologies for the proposed closure approach.

4.6.2.1 Zone A

Zone A begins at the headwaters of Walkers Run (V notch Weir), adjacent to the No. 1 Tank Farm on the western side of Hewes Avenue, extends Southeast past the 10 Plant Separator, and terminates at Post Road. Drawings 1-0-3T/15005A, 15006A, 15007A and 1-0-5A/15083A, 15084A (Volume 2) illustrate the cover design and extent of the coverage method. Zone A is further subdivided into three subzones, A-1, A-2, and A-3.

Subzone A-1

Subzone A-1 extends approximately 475 feet, from the V-notch weir to the east/west culvert traversing Hewes Avenue. Work space on the eastern side of the channel is somewhat restricted by the western side slope of Hewes Avenue, which increases in height to the north. Drawings 1-0-3T/15004A, 15005A, 15007A (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for this subzone.

The stabilization process for subzone A-1 is described as follows:

1. Construct an area for haul truck loading and decontamination. Construction of this area will required subgrade preparation, placement of a geotextile protective layer, and a final 60 mil high density polyethylene (HDPE) or geosynthetic clay layer. Wooden mats will be placed on the liner for protection of truck traffic. The area will be surrounded by a runoff control berm, with a slope and open end draining to the existing conveyance.
2. Divert groundwater and surface waters around work area of the subzone and the Hewes Avenue culvert, as described in Section 5.3, Water Management During Construction.
3. Reroute or demolish major influent storm and process waste water lines, as required. Pipes, concrete surfaces and debris (rocks, riprap, old piping, etc.) within the existing Conveyance will either be left in place and capped over, dismantled and placed beneath the cover, or decontaminated with high-pressure wash in accordance with the techniques described in 40 CFR 268.45 and handled as nonhazardous.

4. Excavate soft sediment to desired elevation. Excavated material will be transported either to the pH Basin, to subzone A-3 (downstream of 10 Plant separator), or to Zone B.
5. Place backfill and or grade as required to produce desired elevations and slope. Mixing of in-place, soft sediment with other material such as cement or fly ash may be conducted if excavation is deemed inappropriate by field personnel.
6. Install a cover system as illustrated in Figure 4-1 (Cap Method 1), which will consist of:
 - Six inches of compacted select soil;
 - A 6-inch layer of sprayed-on, air-entrained concrete (shotcrete).
7. Decontaminate the culvert under Hewes Avenue.

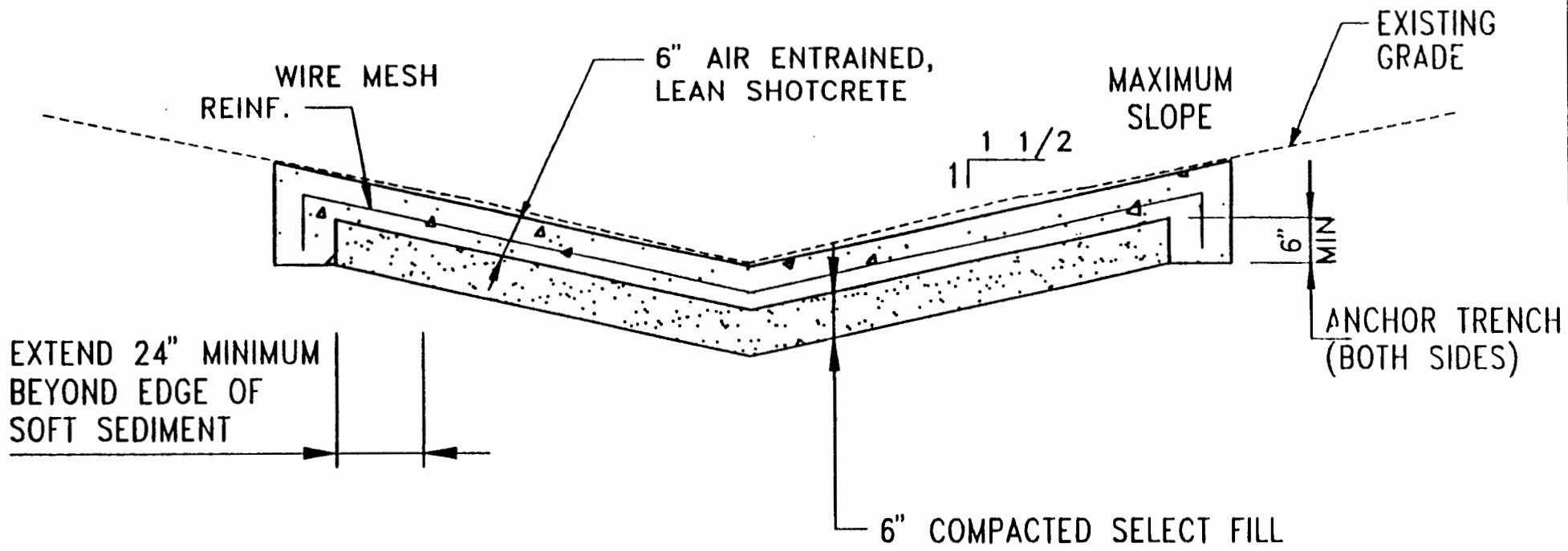
Subzone A-2

Subzone A-2 extends approximately 275 feet southeast from the Hewes Avenue culvert to a 48-inch culvert, southeast of the 10 Plant process area. This area is laden with process and utility piping and pipe rack foundations, which cross the Conveyance. Access through vehicular traffic is therefore not expected. Constructability and ease of installation are key factors in the selection process for capping materials.

Drawings 1-0-3T/15005A, 15006A, 15007A (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for this subzone. The closure procedure is as follows:

1. Construct an area for haul truck loading and decontamination. Construction of this area will required subgrade preparation, placement of a geotextile protective layer, and a final 60 mil HDPE or geosynthetic clay layer. Wooden mats will be placed on the liner for protection of truck traffic. The area will be surrounded by a runoff control berm, with a slope and open end draining to the existing conveyance.
2. Divert ground and surface waters around the work area of the subzone as described in Section 5.3, Water Management During Construction. Construct silt fence at east end of 48-inch culvert.

4-45



CAP METHOD 1

NOTE:
CAP METHOD 1 USED
IN SUBZONES A-1,
A-2 AND ZONE E.



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FIGURE 4-1
CAP METHOD 1
PHASE I STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS Environmental Corporation

DRAWN JFC	SCALE NONE	DATE 9/2/92
APPROVED T. J. RILEY	DRAWING NO. FIG 4-1	SHEET 1 OF 1

3. Reroute major influent storm water and process wastewater lines.
4. Excavate all unsuitable material. Some hand excavation or movement with high-pressure water may be required to maintain the cross section and remove materials in areas of high congestion. Excavated material will either be transported to the pH Basin, sent to subzone A-3 and stabilized as subgrade or fill material, or sent to Zone B for additional removal to the pH Basin.
5. Pipes, concrete surfaces and debris (rocks, riprap, old piping, etc.) within the existing Conveyance will either be left in place and capped over, dismantled and placed beneath the cover, or decontaminated with high-pressure wash in accordance with the techniques described in 40 CFR 268.45 and handled as nonhazardous.
6. Place backfill as required to produce desired elevations and slope. Mixing of in-place soft sediment with cement or fly ash may be conducted, depending on the nature of the material encountered.
7. Install cap as illustrated in Figure 4-1 (Cap Method 1), which will consist, from bottom to top, of the following:
 - A 6-inch layer of compacted, select soil separation/leveling layer.
 - A 6-inch layer of shotcrete.

Subzone A-3

Subzone A-3 extends approximately 120 feet from the 10 Plant Separator discharge pipe to the culvert beneath Post Road. It is anticipated that this subzone will not be stabilized until after completion of the new Conveyance system below Post Road to Station 19+00. Drawings 1-0-5A/15083A, (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for this subzone. This capping system is designed to encourage run-off from the protective cover and into drainage appurtenances located in this subzone. The stabilization procedures are as follows:

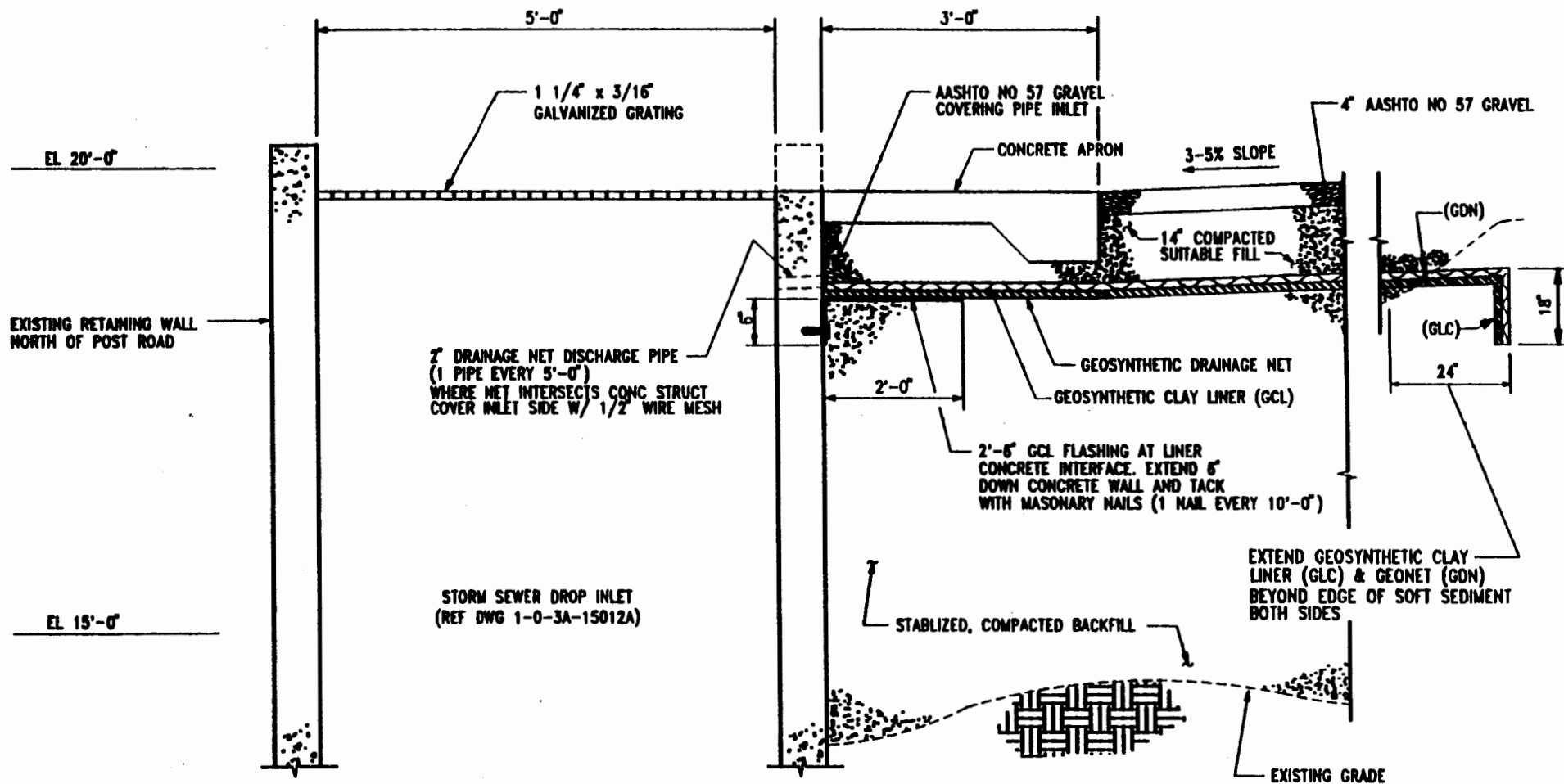
1. Divert surface water and groundwater around the work area of this portion of the channel extending from the 10 Plant Separator to the south side of the Post Road culvert as described in Section 5.3.

2. Decontaminate the inside surfaces of the 6-foot concrete culvert beneath Post Road and temporarily plug at the north end.
3. Stabilize in situ all bottom material with cement, fly ash, and/or fill material as required. The selected material should be capable of producing the required strength characteristics when mixed with the in-place soft sediment.
4. Install catch basins and other drainage appurtenances, as required to pipe 10 Plant and upstream waters to the Conveyance south of Post Road.
5. Install backfill, as necessary, to produce desired elevations, drainage, and slope outside of the drainage appurtenances.
6. Install a cap as illustrated in Figure 4-2 (Cap Method 2), which will consist of:
 - Six inches of compacted select soil.
 - A layer of GCL.
 - A geonet fabric drainage layer.
 - Fourteen inches of select soil.
 - A geotextile fabric.
 - Four inches of gravel (PENNDOT Spec 703.2, Type A, AASHTO Size 57).
7. Restore drainage through reach after cap and drainage appurtenances have been installed and remove plug from Post Road culvert.

Drain holes will be installed into the sidewall of the catch basin on the north side of Post Road, since the cap will have an inward slope in that direction to allow discharge of collected water from the cap drainage layer to the storm water conveyance.

4.6.2.2 Zone B

Zone B extends from Post Road approximately 2,000 feet down Walkers Run to the confluence with Middle Creek (near Conveyance Station 19+50). Two different stabilization capping methods are applicable, one which abuts the new concrete channel and the other in locations that do not abut the new channel.



CAP METHOD 2

N T S

NOTE:

CAP METHOD 2 USED

1N SUBZONE A-3



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FIGURE 4-2
CAP METHOD 2
PHASE I STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS Environmental Corporation

DRAWN JFC	SCALE NONE	DATE 9/2/92
APPROVED T. J. RILEY	DRAWING NO. FIG 4-2	SHEET 1 OF 1

Subzone B-1

This section of zone B includes areas where a concrete cap will be installed, over which a process wastewater pipe will be superimposed over the existing Conveyance. This includes approximately 1,290 feet of the Conveyance, between Conveyance Station 0+00 to 16+35. The underground pipe between Station 4+70 and Station 10+60 will be cleaned to a clean deris surface in accordance with the standard described in 40 CFR 268.45, and either removed, or plugged at all ends because the remaining pipe will then no longer be a hazardous waste. A cap will not be placed over this area (Station 4+70 to 10+60) of the existing Conveyance.

Drawings 1-0-5A/15008A, 15009A, 15010A, 14011A through 14017A, (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for this subzone. The procedures for areas north of Station 7+50 and south of Station 10+60 are as follows:

1. Drive sheet piling into the underlying soil layer, deep enough to accommodate the new concrete channel, where possible.
2. By-pass flow around (or, where applicable, through) the excavated channel, as required for construction of the new concrete channel. Operate groundwater dewatering system during construction and stabilization. Reroute flows into channel as described in the Water Management Plan, Section 5.3.
3. Excavate unsuitable materials within the sheet piling to the pH Basin as required to produce the desired elevations. Alternately, the excavated materials may be placed outside the sheet piling (but within the existing Conveyance) as backfill. Materials will be excavated by means such as dredging, backhoe excavation, clam shovel, etc. Wet sludge and contaminated sediments will be placed into sealed, water tight boxes on roll-off trucks positioned at nearby access points. After loading, the roll off box tops will be closed and the box, truck tires and under-carriage cleaned with a high pressure washer to prevent tracking sludge out of the conveyance area.
4. Stabilize in situ all materials outside the sheet piling with cement, fly ash, fill material and/or dewatering (as required) and compact.
5. Where necessary within the sheet piling, backfill with select materials and compact to provide structural support for the concrete cap.

6. Construct the new concrete cap and process wastewater line as shown on the drawings.
7. Where necessary outside the sheet piling (but inside the old Conveyance), grade to drain.
8. Place backfill and or grade as required to produce desired elevations and slope.
9. Adjacent to the concrete cap within the channel, install a cap system (Cap Method 3, see Figure 4-3), which will consist of:
 - Six inches of compacted, select soil (may be part of the backfill layer).
 - A low-permeability member consisting of a GCL.
 - A geonet drainage layer.
 - Nine inches of compacted, select fill.
 - One layer of geotextile fabric.
 - Nine inches of gravel (AASHTO No. 57 size)

Details of the cap system at the edge of the concrete cap are shown in Figure 4-4. Drain holes will be installed into the sidewall in areas where the cap has an inward slope in the direction of the Conveyance.

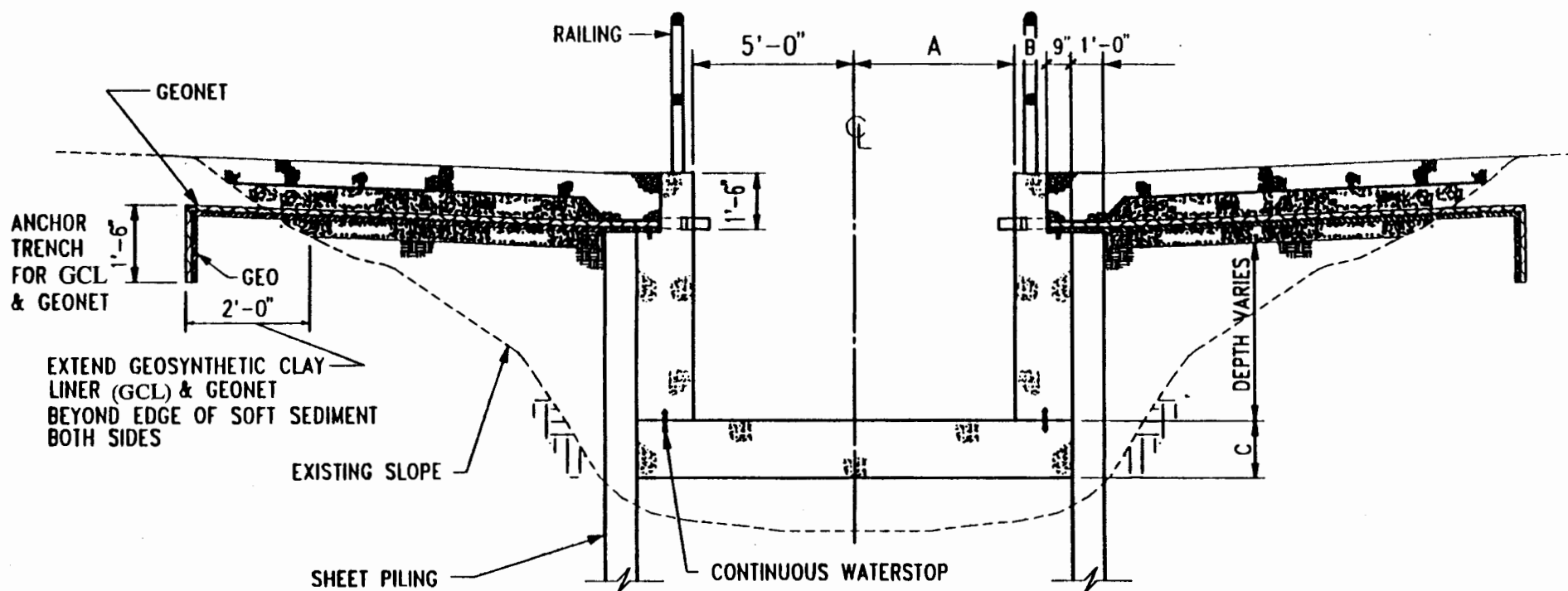
Subzone B-2

Zone B-2 does not include any portions of the existing conveyance and is therefore not subject to RCRA closure. Stabilization activities are not necessary for this subzone. This subzone includes portions of the new Conveyance and has been designated only for purposes of the overall Middle Creek Abatement Project, of which the stabilization actions described in this Work Plan are part.

Subzone B-3

Subzone B-3 consists of the area where a concrete cap is not being installed. It extends from Conveyance Station 16+35 approximately 400 feet to confluence location (where the new concrete channel does not superimpose the existing Conveyance, see Drawing 1-0-5A/15010A, 15011A, 14017A, 15018A, Volume 2).

Drawings 1-0-5A/15015A, 15017A, 15019A, (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for this subzone. Stabilization will occur as follows:



CAP METHOD 3

SCHEDULE FOR CONCRETE DIMENSIONS

STATION LOCATION	A	B	C
0+00 +0 24+00	5'-0"	1'-0"	1'-9"
24+00 +0 35+31	7'-0"	1'-0"	2'-10"

NOTE:
CAP METHOD 3 USED IN
SUBZONES B-1,D-1,D-2

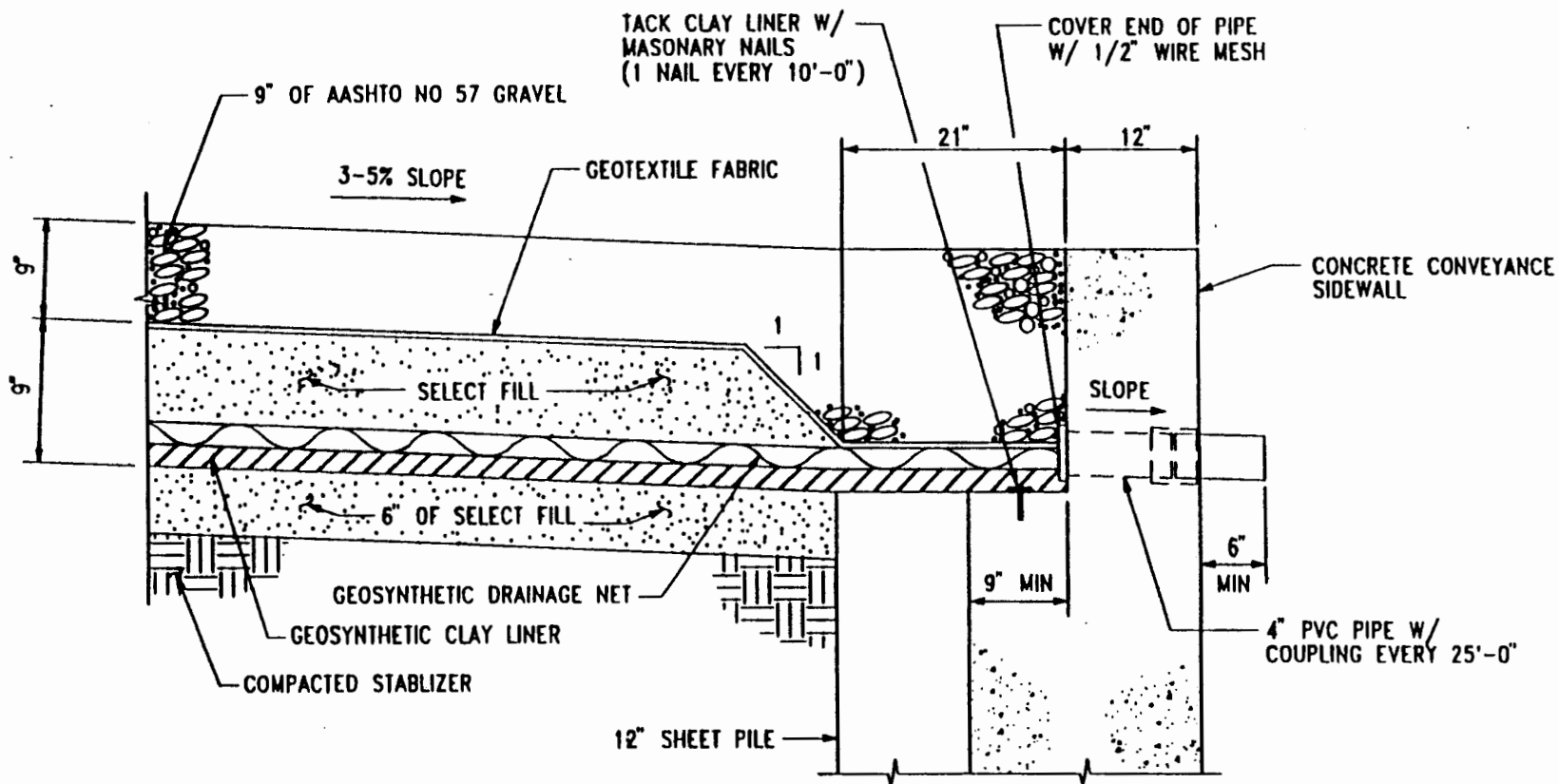


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FIGURE 4-3
CAP METHOD 3
PHASE I STABILIZATION MEASURES WORK PLAN

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CAP METHOD 3 DETAIL



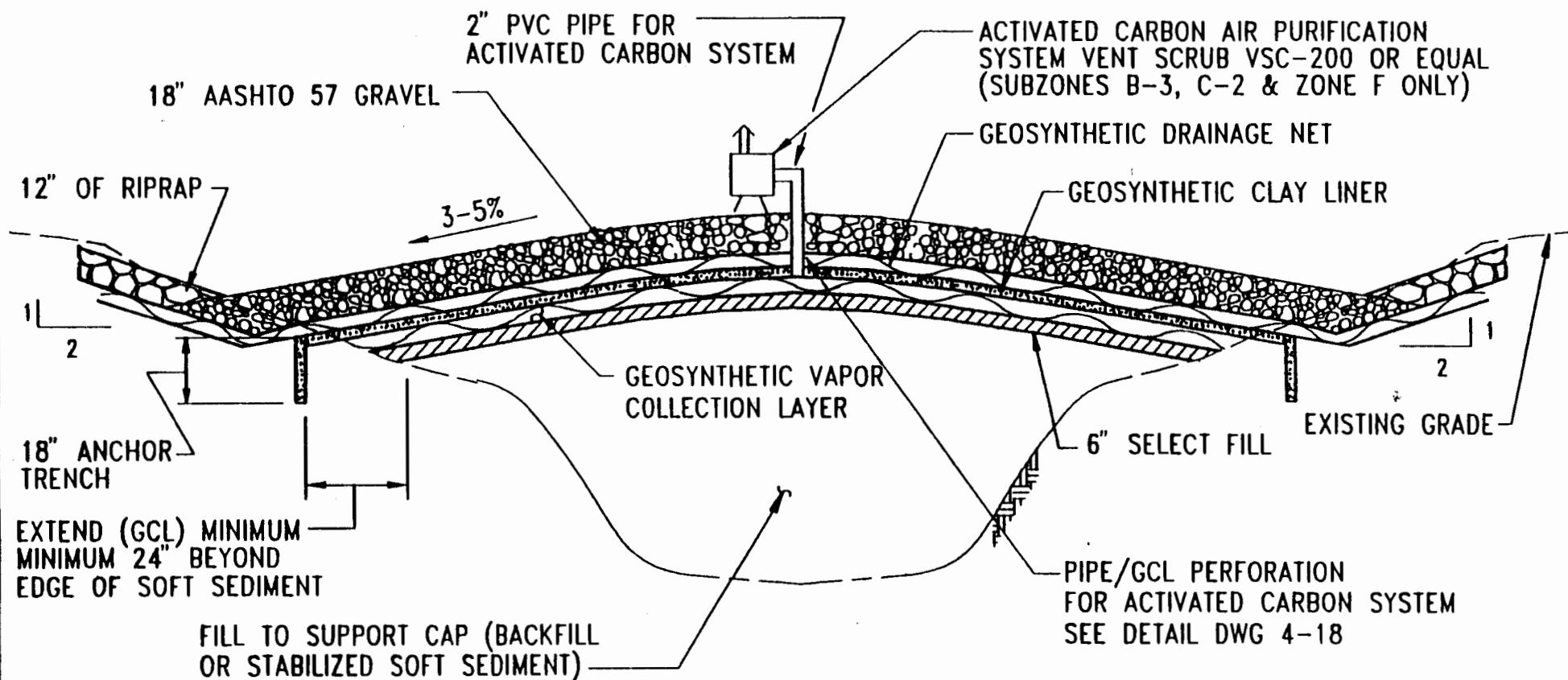
MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK REFINERY
MARCUS HOOK, PENNSYLVANIA

FIGURE 4-4
CAP METHOD 3 DETAIL
PHASE I STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS Environmental Corporation

DRAWN ENZ	SCALE NONE	DATE 10/7/92
APPROVED T. J. RILEY	DRAWING NO. FIG 4-4	SHEET 1 OF 1

1. Divert waters around this portion of the channel as described in the Water Management Plan, Section 5.3.
2. Decontaminate, as required, or decontaminate and remove obstructions (such as the old bridge near the confluence of MiddleCreek and Walkers Run) that cannot be safely or economically capped over. All outstanding obstructions, such as the wooden bridge just south of Middle Creek Road, will be demolished and either placed in the existing Conveyance under areas to be capped, or treated to a clean debris surface and handled as nonhazardous. Obstructions that can physically fit into the channel can be dismantled as required, placed in the channel, and capped over.
3. Stabilize soft sediment as necessary. Backfill with select materials, and grade and compact to produce desired slopes and elevations.
4. Install closure cap (Cap Method 4, see Figure 4-5) which, from bottom to top layer, will include the following:
 - Six inches of a select soil separating/leveling layer.
 - A geonet vapor collection layer.
 - A low-permeability GCL layer.
 - A geonet drainage layer.
 - An erosion protection layer consisting of 9 inches of select fill and 9 inches of gravel to a total thickness of 18 inches above the low-permeability layer. All materials must be keyed into suitable soils adjacent to the channel. A drainage ditch shall be constructed at the cap/existing grade interface, which shall act to collect runoff and prevent run-on. The ditch side slope on existing grade shall be covered with 12 inches of riprap.
5. Install a 2-inch polyvinyl chloride (PVC) pipe extending from the vapor collection layer to an activated carbon vapor absorption unit, installed atop the protective cover layer at locations shown on the drawings. Penetrations of the GCL shall be installed as shown in the details on Drawing 1-0-5A/15015A (Volume 2).



CAP METHOD 4

NOTE:
CAP METHOD 4 TO BE
USED IN SUBZONES
B-3, C-2, D-2, AND
ZONE F.



MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK REFINERY
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FIGURE 4-5
CAP METHOD 4
PHASE I STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS Environmental Corporation

DRAWN JFC

SCALE NONE

DATE 9/2/92

APPROVED T. J. RILEY

DRAWING NO. FIG 4-4

SHEET 1 OF 1

4.6.2.3

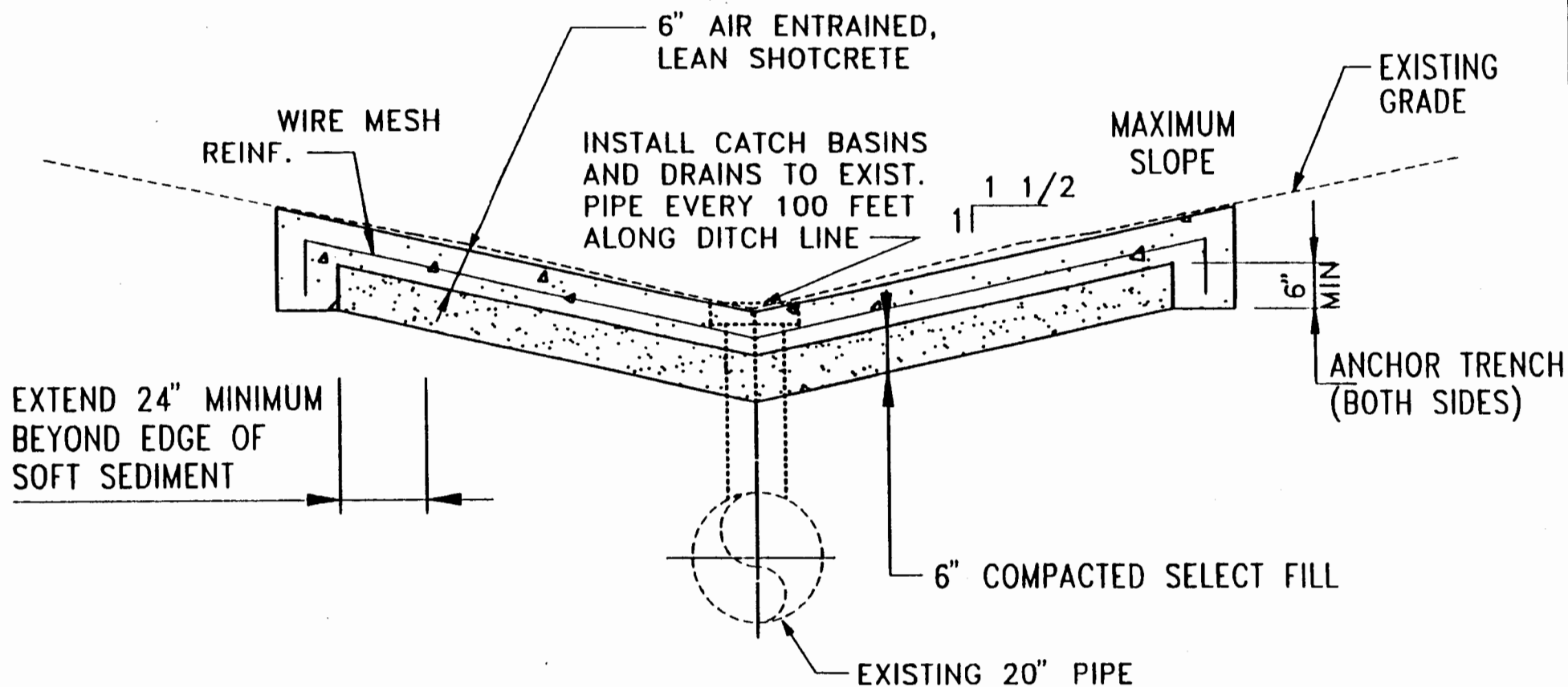
Zone C

Zone C extends from the confluence area approximately 1,030 feet east toward Green Street. This includes 660 feet of a drainage ditch closest to Green Street east of a pipe beneath railroad tracks (referred to as Subzone C-1); 90 feet of pipe; and 280 feet of drainage ditch extending from the pipe to west to the confluence. Of this 280 feet, 90 feet will have been covered and addressed by the new concrete Conveyance in Subzone B-3. Therefore, a total of 190 feet (Subzone C-2) will require closure and capping west of the railroad culvert.

Subzone C-1

Drawings 1-0-5A/15018A, 14028A, 14029A (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures to be implemented for this subzone. These measures include the following:

1. Grade area into a V-shaped ditch. Excavate unsuitable material (i.e., material that does not possess sufficient strength and compaction characteristics) and remove to an area that will be capped. Where necessary, backfill with select materials, compact to support the cap, grade to drain to new catch basins (see Measure No. 2, below).
2. Install catch basins at regular (approximate 100-foot) intervals and drain catch basins to existing 20-inch carbon steel drainage pipe buried beneath ditch. Extend pipe to the process pipeline within the concrete conveyance.
3. Decontaminate, as required, or decontaminate and remove obstructions (such as the concrete culvert near the confluence of Middle Creek and Walkers Run) that cannot be safely or economically capped over. All outstanding obstructions shall be demolished and either deposited in the existing Conveyance for capping, or treated to a clean debris surface in accordance with 40 CFR 268.45 and handled as nonhazardous. Obstructions that can physically fit beneath the cover can be dismantled as required, placed in the channel, and capped over.
4. Install closure cap (Cap Method 5), as shown on Figure 4-6. This cap will consist of the following:
 - A 6-inch layer of compacted, select soil.
 - A 6-inch layer of shotcrete.



CAP METHOD 5

NOTE:
CAP METHOD 5 USED
IN SUBZONES C-1



MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK REFINERY
MARCUS HOOK, PENNSYLVANIA

FIGURE 4-6
CAP METHOD 5
PHASE I STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS *Environmental Corporation*

DRAWN JFC	SCALE NONE	DATE 9/2/92
APPROVED T. J. RILEY	DRAWING NO. FIG. 4-1	SHEET 1 of 1

Subzone C-2

As described above, this portion of Zone C is west of the railroad culvert. Part of this area will be closed by Cap Method 3. This stabilization method described below is for the remainder of subzone C-2. Drawings 1-0-5A/15018A, 14028A, 14029A (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for this subzone.

1. Divert waters around the work area section of this portion of the Conveyance. Install dewatering system as required. Reroute drainage and demobilize dewatering system when work is completed.
2. Decontaminate, as required, or decontaminate and remove obstructions that cannot be safely or economically capped over. Obstructions that can physically fit into the channel will be dismantled as required, placed in the conveyance, and capped over.
3. Excavate unsuitable material (i.e., material that does not possess sufficient strength and compaction characteristics) and remove to an area within the Conveyance for later consolidation. Where necessary, backfill with select materials and grade to produce desired slopes and elevations, and compact.
4. Cap Method 4 (see Figure 4-5) will be installed as described for subzone B-3.

4.6.2.4 Zone D

This zone extends from the confluence location (channel Station 20+00) approximately 2,000 feet to Blueball Avenue. A concrete cap (including sumps) will be superimposed upon the existing Conveyance through this zone. Wastewater and storm water from the new channel will each discharge into a dedicated sump at the western end. Drawings 1-0-5A/15011A through 15017A, and 14035A through 14041A (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for subzones D-1 and D-2.

Subzone D-1 extends approximately 1,500 feet from Station 20+00 to Station 35+31, where the new channel ends. Subzone D-2 extends approximately 205 feet from Station 35+31 to Blueball Avenue. The new east process sump and storm water sump are located in subzone D-2.

Subzone D-1. New Conveyance Segment

Cap Method 3 (see Figure 4-3) will be used in this subzone from Station 20+00 to Station 29+07. Since a drainage swale is required in this area east of the railroad crossing between Station 29+07 to Station 32+90, the north side of the new concrete Conveyance will be capped with reinforced concrete pavement. Drawings 1-0-5A/14039A and 14040A are the cross sections illustrating the capping arrangement. Drawing 1-0-5A/14060A, 14061A and 14065A illustrate the extent of concrete capping, section E-E showing concrete paving detail, and control joint layout, respectively, for this area.

South of the Conveyance between these stations, the GCL capping scheme, as shown in Figure 4-3, will be used. Decontaminate as required or decontaminate and remove obstructions (such as the railroad bridge at Station 33+50) that cannot be safely or economically capped over. Treat these obstructions to a clean debris surface in accordance with 40 CFR 268.45. Alternately, these obstructions will be dismantled and placed in the existing Conveyance under areas to be capped. Construct new caps as described for subzone B-1. Excavation of soft sediments in this zone will be accomplished early in the project to increase the rate of Flow from upstream locations.

Subzone D-2. Sumps

1. Drive sheet piling across the existing conveyance 10 feet east of Blueball Avenue.
2. Divert water from the existing channel over the sheet piling to dewater all the area east of Blueball Avenue.
3. Construct sheet pile bulkhead around area to be excavated for the new sumps.
4. Excavate as required for the new sumps. The excavated soft sediments and affected soils can be deposited along the existing Conveyance or in the pH Basin on the condition that it will ultimately be under a portion of the cap. Deeper excavated materials will be managed in accordance with the Waste Material Classification Plan described in Section 5.5.
5. Install sumps.
6. Where necessary outside the sumps (but inside the old Conveyance), stabilize as necessary to support the cap backfill with select materials,

grade to drain, compact. Cap Method 3 (see Figure 4-3) will be used in this subzone. Construct cap as in subpart B-1.

This capping system for the Conveyance east of the Blueball Avenue bridge will be temporarily ended here by sloping the cap from the top of the sump to the channel invert approximately 50 feet beyond the west side of the stormwater sump, as shown in Drawings 1-0-5A/15033A and 15035A.

4.6.2.5 Zone E - Backwater Area

The impoundment basin backwater, which is designated as Zone E, is a drainage ditch that extends approximately 1,140 feet from the point where the Conveyance passes beyond a railroad bridge west of Blueball Avenue, west along the north side of 15 Plant Separator and the Solids Handling Facility. The width of the ditch ranges from 3 to 23 feet. Culverts, railroads, and other obstructions within the existing Conveyance which cannot be removed and which cannot safely or economically fit beneath the cap shall be treated to a clean debris surface in accordance with 40 CFR 268.45. If the obstruction is to be dismantled, the materials will either be placed beneath the cap or treated to a clean debris surface and disposed of off site as a nonhazardous waste.

The closure cap installation is based on the assumption that maintenance of a storm water drainage channel through the backwater area is required. However, only minor runoff from the railroad track area south of the channel is expected. Drainage from Middle Creek Road will be directed into a series of catch basins and piped to the storm water sump. Process waters will be collected in the West Process Sump and pumped to the East Process Sump. Drawings 1-0-5A/15029A, 14071A, and 14069A illustrate the new storm water drainage system adjacent to the Backwater Area. Drawings 1-0-5A/25069A and 25070A illustrate the extent of cap coverage through Zone E. The cross section of the Zone E cap is shown on Drawing 1-0-5A/25071A. The method of closure includes the following:

1. Divert groundwater and surface waters around the subzone and restore flow after work is completed.
2. Reroute major influent storm water and process wastewater lines.
3. Excavate soft sediment to desired elevation. Mixing of in-place, soft sediment with other material, such as cement or fly ash, may also be conducted if excavation is deemed inappropriate by field personnel. Excavated material will be transported to the pH Basin.

4. Place backfill and or grade as required to produce desired elevations and slope.
5. Install storm water collection sump at east end of Zone E. Adjacent to the sump, install a cover system, as illustrated in Figure 4-3 (Cap Method 3).
6. For the remainder of the Zone E ditch, install a cover system, as illustrated in Figure 4-1 (Cap Method 1), which will consist of:
 - Six inches of compacted, select soil.
 - Six inches layer of shotcrete.

4.6.2.6 Zone F - pH Basin

Zone F (the pH Basin) extends from Blueball Avenue west 540 feet to the concrete dam which currently impounds the drainage from the upstream portions of the Conveyance. The pH Basin width varies from 50 to 80 feet. The pH Basin will be used as a consolidation area for material excavated in the conveyance, of primary sludge solids from upstream units and the surge tank T101 during stabilization activities. Basin preparation is described in Section 4.6.1.3. Culverts, railroads, and other obstructions within the existing Conveyance which cannot be removed and which cannot safely or economically fit beneath the cap shall be treated to a clean debris surface in accordance with 40 CFR 268.45. If the obstruction is to be dismantled, the materials will either be placed beneath the cap or treated to a clean debris surface and disposed of off site as a nonhazardous waste. Drawings 1-0-5A/25069A and 25071A (Volume 2) illustrate the cap design and extent of coverage for the stabilization measures implemented for Zone F. The Basin will be stabilized upon completion of the Conveyance construction in the following manner:

1. Remove dewatering system from the consolidation area.
2. Stabilize consolidated sediment materials within the sheet piles as necessary to support a cap. Remove sheet piling as required to produce the necessary final slopes.
3. Backfill the two 60 inch drainage pipes used for construction water management and plug both ends with concrete; or remove, clean and reuse; or remove and reuse as scrap metal.
4. Grade stabilized sediments to produce desired outslopes of the consolidated materials.

5. Backfill drainage channel along the south side of the sheet piling with stabilized soft sediment or stable fill.
6. Install closure cap (Cap Method 4, see Figure 4-5), as described for Subzone B-3.

The cap will extend over the backfilled and stabilized materials existing within the consolidation area as well as the channel maintained for Conveyance drainage during construction (south of the sheet pile area). All cap materials must be anchored into suitable soils adjacent to the basin and channel.

4.6.2.7 General Stabilization Measures

In addition to the specific stabilization measures described for the zones above, other general requirements for stabilization activities are applicable to all zones.

- All backfill will be well contoured such that all outslopes are no steeper than three to one.
- Prior to installation of GCL, protrusions and rocks in select fill layers larger than 2 inches in diameter will be removed and the entire backfill compacted to the extent that the installation equipment does not make tracks.
- Use of sheep's-foot rolling equipment will not be permitted for compaction of materials above or below the GCL.
- The GCL will be at least 18 inches below the ground surface, according to manufacturer's specifications.
- All capping materials will be anchored into suitable soils adjacent to the channel.
- GCL liner seams will require a uniform 6-inch overlap.
- GCL will never be installed in standing water. If rainfall commences during installation, the GCL will be covered with visquene for interim protection.
- Vehicular traffic directly on the GCL without the support of backfill will not be permitted. However, the GCL is capable of supporting installation personnel.

- Any material excavated from areas outside the existing Conveyance that cannot be used as fill for the new system and cannot be deposited in the pH Basin for lack of capacity will be disposed of as appropriate, depending upon the results of chemical analysis.
- Details on the penetration of capping materials by pipes and other structures are detailed on the following drawings, located in Appendix 2 of this work plan:

Type of Structure	Drawing Number
Horizontal and vertical pipe through clay cap	1-0-5A/15084A
Horizontal and vertical pipe through shotcrete cap	1-0-3T/15007A
Concrete structure through clay cap	1-0-5A-15084A

- To the extent possible, buried pipes will not be placed under the cap. However, in some locations, existing utility and process pipelines must remain beneath the cap. At other locations, it is required that drainage collection devices discharge to pipelines for conveyance out of the stabilized areas.
- Soils used as backfill obtained from outside the existing Conveyance will not contain hazardous wastes.

4.7

SCHEDULE

A preliminary schedule detailing implementation of the stabilization measures outlined in the Work Plan for Middle Creek Abatement Project is provided in Figure 4-7. This figure contains Activity ID numbers which outline work areas for the contractor. The work areas are as follows:

Activity ID	Work Area
1000 through 1045	Mobilization, Training and work on Sump #7, a sump outside the scope of the Middle Creek Stabilization Measures.
1100 through 1120	Work in Zone A near Post Road next to No. 10 Separator.
1200 through 1270	Work in Zone B from Post Road to Station 15 + 25.
1300 through 1335	Concrete Conveyance installation in Zone B from Station 15 + 25 Zone D Station 20 + 50, which includes work on Middle Creek Road.
1400 through 1445	Zone D concrete Conveyance installation from Station 20 + 50 to 35 + 31 and capping in Zones B, C, and D.
1500 through 1540	Work in the areas of Zones E&F and the Process and Storm Water Sumps.
1600 through 1640	Work on the Surge Tanks outside the scope of Middle Creek Stabilization Measures.
1700 through 1725	Zone A capping.

The Figure 4-7 schedule does not include the capping of Zones E and F (pH Basin and backwater area). This schedule is:

Zone E & F	Beginning Date	Ending Date
Stabilize/Excavate/Grade	28/Apr/94	02/Sept/94
Install Catch Basins	26/Sept/94	03/Oct/94
Install Cap	07/Oct/94	30/Mar/95
Remove Dewatering System	31/Mar/95	03/May/95

FIGURE 4-7

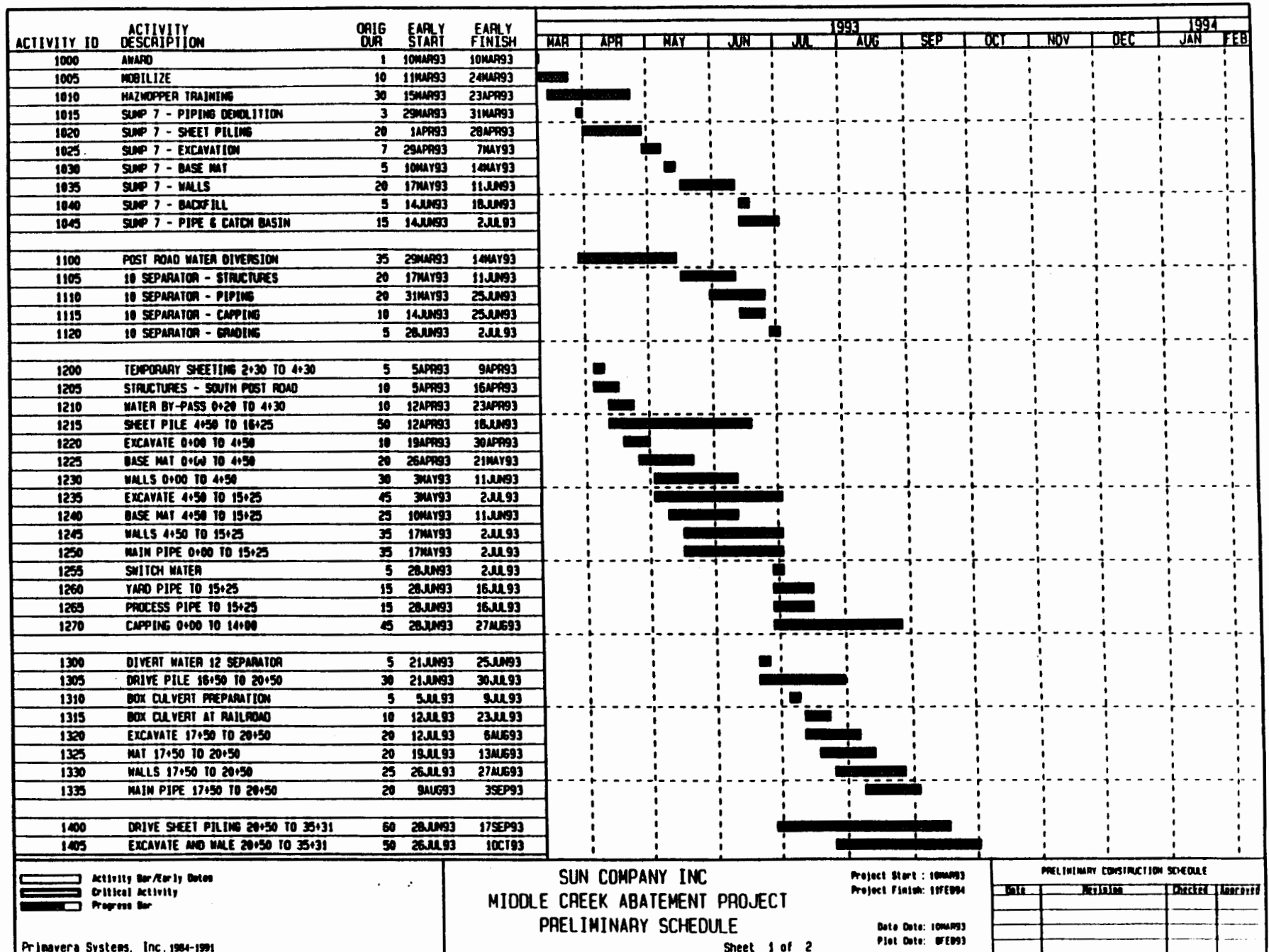
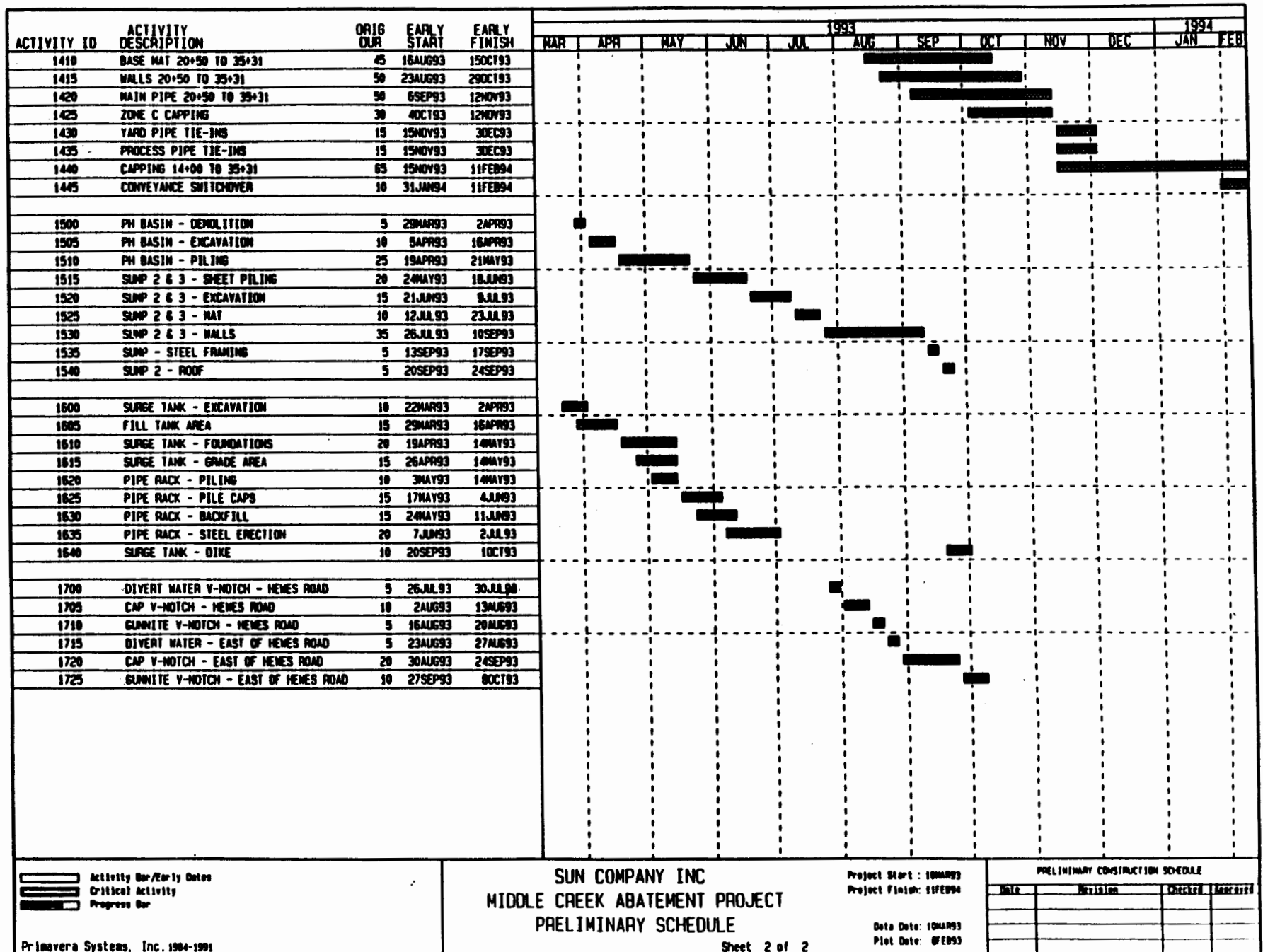


FIGURE 4-7 (CONTINUED)



Once the contractor is selected and mobilizes the field crew, a Detailed Master Schedule will be created which will include:

- Activity sequence and logic with all plans
- Manpower projection curve
- Major Milestone Activities

REFERENCE LIST - SECTION 4.0

Commonwealth of Pennsylvania, 1990. "Specifications 1990," Department of Transportation, Publication 408, PENNDOT.

EPA (U.S. Environmental Protection Agency), 1989. "Final Covers on Hazardous Waste Landfills and Surface Impoundments." EPA 530-SW-89-047, July.

EPA (U.S. Environmental Protection Agency), 1991. "Stabilization Technologies for RCRA Corrective Actions." EPA 625 6-91-026, August.

James Clem Corporation Product Literature, May 1992. Chicago, Illinois.

5.0 WASTE AND MATERIAL HANDLING

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5.0 WASTE AND MATERIAL HANDLING

5.1 INTRODUCTION

Various waste materials will be managed during the course of the stabilization activities. These include the following:

- Soft sediment and contaminated soil excavated from Middle Creek.
- Sludge from upstream units and the surge tank T-101 which have been managed in Middle Creek.
- Soil from areas other than Solid Waste Management Units (SWMUs).
- Riprap.
- In-place equipment spoils and debris.
- Construction waste and debris.
- Decontamination solutions and wastes.
- Sampling and analysis wastes.

Table 5-1 summarizes the anticipated quantities and the final disposition of these materials.

Waste and material handling is subject to the following general constraints in order to comply with applicable regulatory requirements and to implement interim stabilization measures:

- At the completion of the project, hazardous waste excavated from the Conveyance will remain within portions of the Conveyance under a capped portion.
- Refinery soil used as filler or stabilization material in the Conveyance will be nonhazardous.
- Waste, such as debris and riprap, that is currently located within the Conveyance will not be removed, unless it interferes with the construction of the RCRA cap or the new channel. Such debris may be decontaminated in accordance with 40 CFR 268.45 and handled as

**TABLE 5-1
MATERIAL QUANTITIES AND DISPOSITION**

Material	Approximate Quantities (cu.yds.)	Disposition
Soft Sediment and Soil Excavated from Conveyance	26,000	Redeposition in Conveyance or offsite disposal as hazardous waste.
T-101 Sludge	1,500	Deposition in Conveyance
Riprap	45	Hazardous - Disposal in Middle Creek under the cap, offsite disposal as hazardous waste, or decontamination and offsite disposal as nonhazardous waste.
In-place Equipment Spoils/Debris	5 - 10	Same as riprap
Construction Waste/Debris	5 - 10	Same as riprap
Decontamination Solutions	< 1	Aqueous - Transport to downstream Middle Creek zones. Corrosives - Offsite treatment or disposal as hazardous waste or neutralization and transport to downstream zone. Nonhazardous - Offsite disposal as nonhazardous waste.
Sampling/Analysis Wastes	< 1	Hazardous - Offsite disposal or treatment as hazardous waste. Nonhazardous - Offsite treatment/disposal as nonhazardous waste.

a nonhazardous (residual) waste. Debris decontamination techniques are discussed in Section 5.4.

- Waste that is transported off site for disposal will be characterized to determine whether it is hazardous or nonhazardous. Waste material classification is discussed in Section 5.5. If hazardous, the waste will be managed in accordance with applicable hazardous waste regulatory requirements, including Land Disposal Restrictions (LDRs) contained in 40 CFR 268. If nonhazardous, the waste will be managed in accordance with applicable residual waste regulatory requirements.
- Sludge from upstream units and surge tank T-101 will be managed within areas of the existing Conveyance which will be capped.

Section 5.2 of this document discusses each of the major categories of waste material management practices, decontamination techniques, methods for evaluating the effectiveness of decontamination, and the requirements for the ultimate disposition of hazardous and nonhazardous waste materials and decontamination residues. Section 5.3 contains a discussion on water management during construction. Section 5.4 contains a general description of debris decontamination techniques. Section 5.5 discusses criteria for determining waste material classifications. Section 5.6 discusses pollution prevention measures to be implemented during waste and material handling.

5.2 MATERIAL HANDLING PRACTICES

5.2.1 Sediment and Underlying Sediment Excavated from the Conveyance

The soft sediment in the Conveyance is a listed hazardous waste with the RCRA waste codes of F037 (primary oil/water/solids separation sludge) and/or F038 (secondary oil/water/solids separation sludge). Some material exhibits the toxicity characteristic (TC). Based on historical sampling results, however, only one soft sediment sample exceeded a TC regulatory level. This sample exhibited the TC for benzene. Underlying impacted sediment excavated from the existing Conveyance would also be a hazardous waste because it contains a listed hazardous waste (contained-in policy). Based on historical data, none of the underlying sediment samples exhibited the toxicity characteristic. These materials are not expected to exhibit the characteristics of ignitability, corrosivity, or reactivity based on previous testing and knowledge of the wastes.

All of the soft sediment and underlying sediment that is excavated from the Conveyance at the refinery will be deposited underneath capped portions of the existing Conveyance. Offsite disposal of any of this material (if required) will be in accordance with hazardous waste management regulations. Additional details on the management of soft sediment are provided in Section 4.0, Technical Approach.

5.2.2 Surge Tank T-101 Sludge

Surge tank T-101 is the overflow mechanism for the Conveyance. Both T-101 and the Conveyance are part of the refinery wastewater treatment system. Primary sludge solids (F037/F038) that have been conveyed, suspended in the water, as the result of normal operations of the Conveyance, including cleaning of units that feed into the Conveyance or water and solids received from units such as T-101, or the movement of solids as part of the closure of tank T-101 and other units, will be part of the inventory that will be managed within the existing Conveyance during stabilization activities. The areas of the Conveyance where this management will take place will eventually be capped.

5.2.3 Riprap

Riprap consists of rocks and similar materials found in the Conveyance. Contaminated riprap can be (1) left in place if it will not interfere with construction of the new channel or cap, (2) placed within an area that will be capped, (3) disposed of off site as hazardous waste, and/or (4) decontaminated and disposed of off site as a nonhazardous (residual) waste.

Techniques used for decontamination may consist of water sprays and, if necessary, steam cleaning. Decontamination will take place within designated decontamination areas that are bermed and lined or otherwise designed and constructed to contain and prevent the migration of decontamination solutions and materials. Aqueous decontamination solutions will be transported directly to a downstream zone of the channel for treatment at the refinery's wastewater pretreatment facility. To render it nonhazardous, riprap will be cleaned until all discoloration and visible evidence of soft sediment contamination are removed.

In the event that water washing or steam spraying is ineffective, as shown by visible evidence of contamination, treatment technologies such as abrasive blasting or acid washing may be used. If abrasive blasting is used, approximately 0.6 centimeters of the surface layer and all visible staining will be removed. Residues from abrasive blasting would still be a hazardous waste. If acid washing is used, all visible staining will be removed. Wastes from acid washing will be managed on site or off site. If managed on site,

they will be neutralized and handled as an aqueous waste by transportation to a downstream zone. If sent off site, they will be handled as a hazardous waste.

5.2.4

In-Place Equipment Debris

The category of in-place equipment debris consists of equipment associated with the existing Conveyance. This includes pipes, foundation works, sheet piling, ladders, and stairs. The options for handling and management of these debris materials are the same as for riprap.

The decontamination techniques anticipated (if this option is selected) include abrasive blasting, acid washing, scarification and grinding, spalling, and water washing and spraying. The exact technique will be chosen based on factors including the type of equipment, location of the equipment, accessibility of contamination (i.e., exterior, interior), type of contamination, and the ultimate disposition of the equipment debris. To the extent possible, decontamination will take place on plastic-lined pads, particularly if acid washing is to be used.

To the extent possible, decontamination residues will be handled within the existing Conveyance. Wastewater from water washing and spraying will be discharged to the next downstream zone for treatment at the refinery wastewater treatment facility. Wastes generated during abrasive blasting, scarification and grinding, and spalling will be handled in one of two ways. If compatible with the soft sediment, they will be placed within the Conveyance in areas which will be overlaid by the new channel and cap. The other option is offsite disposal, with the disposal option dependent upon the hazardous characteristics/listing (if hazardous) or on the residual waste classification (if nonhazardous). Wastes from acid washing will be managed on site or off site. If managed on site, they will be neutralized and handled as an aqueous waste by transportation to a downstream zone. If sent off site, they will be handled as a hazardous waste.

The techniques for evaluating the success of decontamination will depend upon the decontamination technique employed. In the case of metals, all paints, surface coatings, rust, scale, corrosion, and visible staining will be removed. In the case of brick, concrete, rock, and pavement-type waste materials, all paints, coatings, and visible staining will be removed. In addition, if abrasive blasting, scarification and grinding, or spalling is used for brick, concrete, rock, and pavement-type waste materials, removal of approximately 0.6 cm of the surface layer will be evidence of successful decontamination.

In areas where the existing Conveyance consists of pipes rather than an earthen conveyance, the pipe will be cleaned, plugged, and abandoned. Water washing and spraying techniques will be employed.

5.2.5 Debris

Debris consists of items such as wood, railroad ties, and other trash. The options for handling and management of these debris materials are the same as riprap and in-place equipment debris. A particular type of debris may be decontaminated (if this option is selected) using techniques described for in-place equipment debris. Any decontamination residues will be handled as described for in-place equipment debris decontamination residues. Debris that has been successfully decontaminated or shown not to be contaminated will be reused or handled as a nonhazardous waste.

If decontamination is not selected, is not feasible, or is not successful, the debris will be handled as a hazardous waste. Contaminated debris may be transported to a portion of the existing Conveyance, which will be capped. Alternatively, contaminated debris may be sent off site for treatment or disposal as a hazardous waste.

5.2.6 Construction Waste

Construction waste includes forms, packaging material, office waste, discarded personal protective equipment (PPE), excess cement, forming slag, and other construction-related materials. Waste materials such as forms, packaging material, office waste, excess cement, and forming slag are expected to be nonhazardous and will be sent off site for disposal as a residual waste. PPE contaminated with soft sediment or contaminated debris will be deposited under an area of the Conveyance to be capped, or disposed off site, or decontaminated. Otherwise, PPE will be handled as a residual waste.

5.2.7 Decontamination Residue

The disposition of decontamination residues has been discussed in the sections on wastes specific to the types of waste materials being decontaminated. The Land Disposal Restriction (LDR) treatment standards for decontamination residue are the same as for the waste that contaminated the debris.

5.2.8 Sampling and Analysis Wastes

All sampling and analysis wastes generated will be handled as hazardous if they fit the hazardous waste classification or listing criteria described in Section 5.5. Treatment and disposal is generally expected to take place off

site and will be in accordance with requirements for the particular classification of sampling and analysis waste.

5.3 WATER MANAGEMENT DURING CONSTRUCTION

5.3.1 Present Water Management System

Storm water from the operating areas and process wastewater at the Marcus Hook refinery are currently carried in a common earthen conveyance (Middle Creek). The Middle Creek Conveyance is a 1.5-mile-long, open wastewater conveyance system located within the Marcus Hook refinery. In the east and west process areas of the refinery, combined process wastewaters and storm water are processed through API or CPI separators to cause the oil in the water to separate for removal by skimming from the water surface. Suspended solids separate by gravity and are removed as sludges. Wastewater streams leaving the oil/water separators, product tank drawdown water, non-contact cooling water, steam plant blowdown, steam trap condensate, and storm water are combined in the Middle Creek Conveyance for transport to an interceptor dam. This dam retains the water for diversion through a final oil/water separator (5 bays of the 15 Plant Separator) prior to discharge to a publicly owned treatment works (POTW) operated by the Delaware County Regional Authority (DELCORA). The impoundment behind the dam is used for primary pH adjustment and sedimentation before the wastewater is treated in the final separator, where acid or caustic can also be added to adjust the final pH to the desired level. A 12.5-million-gallon-capacity tank (T-101) is used to hold water from the interceptor basin, in the event of heavy rainfall runoff, until the water can be processed through the final separator. The treated water is then pumped to DELCORA for biological treatment and subsequent release to the Delaware River. Data for the volume of water pumped to DELCORA during 1991 show that the average dry weather flow in the Conveyance (the process wastewater) is 3500 gpm with an average maximum flow of 4500 gpm. These data are included in Appendix 5.1. During periods of extremely high storm flow, when the capacity of T-101 is exceeded, the excess water is diverted to the Delaware River.

A wide range of fuels, lubricants, and chemicals are produced from crude oil at Marcus Hook. The refinery has processing units in the eastern and western areas and tankage in the central section of the site. Process wastewater consists of waters that have been in direct contact with crude oil or any of several intermediate or product streams, where the water can become contaminated with suspended oil or soluble organic materials. Drawdown water that separates in product storage vessels can also contain suspended oil and dissolved organics. The noncontact cooling water, steam plant blowdown, and steam trap condensate may contain nonvolatile contaminants, such as

dissolved or suspended solids, and may be elevated in temperature, but these flows are not contaminated with organic materials.

5.3.2 Summary

During the construction phase, temporary piping will be used to convey process wastewater around the construction area. Stormwater will be carried in a temporary open channel constructed along the side of the sheet pile being used to support the wall of the new trench. Early in the construction phase, those waters that are to be discharged through the 84-inch line will be rerouted.

5.3.3 Zone A

A temporary line will be installed to pump water from the V-notch weir at the upper end of Walkers Run to the head end of the existing 48-inch pipe. This line will carry storm water from the tank farm areas around this portion of the ditch while it is being cleaned and shotcreted. Temporary dams will also be installed to pump storm water from the south end of the 48-inch pipe and the gully draining the east area of 10 plant to a temporary pipe installed under Post Road, while permanent structures are being built in these areas. A temporary carbon steel pipe will be jacked under the road to carry process and storm water from the areas north of Post Road during the construction period. The existing 6-ft culvert under Post Road will be cleaned and a temporary plug installed at the north end.

Connections will be made to allow uncontaminated stormwater from the 10 plant area and the north half of Post Road to flow into the line going to Outfall 020 at Manhole #10A and #11.

5.3.4 Zone B

A 48-inch, temporary, corrugated steel culvert will be installed between the south pit and the existing 66-inch concrete pipe that carries Walkers Run underground from the area around Tank 10 to the area by 1-C Separator. Discharge pipes from process areas that presently discharge into Walkers Run will be connected to the 48-inch by-pass by temporary pipes of appropriate size.

The permanent storm water system will be installed from the Conveyance ditch to Manhole #12, and the pipe serving the street inlets on the south side of Post Road will be temporarily connected to it. The existing 36-inch pipe which drains Post Road to Walkers Run will be temporarily plugged.

A pilot trench will be excavated along the path of the sheet piles to an elevation 2-ft below the top of the sheet elevation. This trench will serve as a temporary storm runoff ditch.

Another 48-inch temporary pipe will be installed to convey water from the south end of the existing 66-inch pipe to the existing creek at 12-A separator. Sheet pile will continue to be driven and a bulkhead installed at Middle Creek to prevent the water from backing up into the excavation. Temporary bulkheads will be installed in the process conveyance and the stormwater conveyance at this point also.

Upon completion of construction of the new conveyances to this point, the temporary bypasses will be removed and the waters directed to the proper conveyance.

5.3.5 Zone C & D

The water being conveyed in the new storm water and process wastewater conveyances will be pumped from behind the bulkheads and conveyed in another bypass system to be discharged back into Middle Creek downstream of the sheet pile bulkhead. This bulkhead will be constructed across Middle Creek near the 1-D Separator. Sheet piling will continue to be driven along the length of the proposed conveyance and another temporary bulkhead installed across the creek at Blueball Avenue downstream of the location of the stormwater and east process wastewater sumps. The new conveyances will have temporary bulkheads installed at a point near the 1-D Separator and will be put into service when they are completed. When the sumps are completed all the water will be carried in the new conveyance systems. The area east of Blueball Avenue will be dewatered by pumping over the bulkhead to the pH basin. Capping east of Blueball will then be completed.

5.4 DEBRIS DECONTAMINATION TECHNIQUES AND PERFORMANCE STANDARDS

Hazardous debris is defined as a solid material (that is not a process waste) having a particle size exceeding 60 mm (2.5 in) that is intended for disposal, and which exhibits a hazardous waste characteristic or is contaminated with a listed hazardous waste. Debris that is contaminated with hazardous waste and destined for offsite disposal will be either managed as a hazardous waste or decontaminated and managed as a nonhazardous (residual) waste. However, decontamination would not be required if the debris already meets the LDR treatment standard for the hazardous waste with which it is contaminated.

The technologies that are expected to be applicable for decontamination of debris to render it nonhazardous include the following:

- Abrasive blasting
- High pressure steam and water sprays
- Scarification and grinding
- Spalling
- Liquid phase solvent extraction
- Water washing and spraying
- Acid washing

A summary of the applicability of these technologies for various types of debris is presented in Table 5-2.

Following is a description of these decontamination technologies and the performance standards to demonstrate successful decontamination for the various debris types (40 CFR 268.45). Residues from decontamination of debris are subject to the waste-specific treatment standards for the waste contaminating the debris.

5.4.1 Decontamination

5.4.1.1 Abrasive Blasting

This physical extraction technology consists of removal of contaminated debris surface layers using water and/or air pressure to propel a solid media (e.g., steel shot, aluminum oxide grit, plastic beads).

5.4.1.2 High-Pressure Steam and Water Sprays

This physical extraction technology consists of application of water or steam sprays of sufficient temperature, pressure, residence time, agitation, surfactants, and detergents to remove hazardous constituents from debris surfaces to remove contaminated debris surface layers.

TABLE 5-2
DECONTAMINATION METHODS FOR HAZARDOUS DEBRIS

Method	Riprap	In-Place Equipment Debris	Debris
Abrasive blasting	X	X	X
High-pressure steam and water sprays	X		X
Scarification and grinding		X	X
Spalling		X	X
Liquid-phase solvent extraction			
Water washing and spraying		X	X
Acid washing	X	X	X

X - potentially applicable method.

5.4.1.3 Scarification and Grinding

This physical extraction technology consists of a process utilizing striking piston heads or rotating grinding wheels such that contaminated surface layers are removed and dust and airborne contaminant emissions are contained in an enclosure or captured by application of a vacuum at the point of scarification or grinding.

5.4.1.4 Spalling

This physical extraction technology consists of drilling or chipping holes at appropriate locations and depth in the contaminated debris surface and applying a tool that exerts a force on the sides of those holes such that contaminated debris surface layers are removed. The surface layer that is removed is still considered to be hazardous debris and is subject to LDR treatment standards for hazardous debris.

5.4.1.5 Liquid-Phase Solvent Extraction

This chemical extraction technology consists of removal of hazardous contaminants from debris surfaces and surface pores by applying an organic liquid (e.g., non-aqueous solvent) or organic liquid solution that causes the hazardous components to enter the liquid phase and be flushed away from the debris along with the organic liquid or organic liquid solution using appropriate agitation, temperature, and residence time.

5.4.1.6 Water Washing and Spraying

This chemical extraction technology involves an application of water sprays or water baths of sufficient temperature, pressure, residence time, agitation, surfactants, acids, bases, and detergents to remove hazardous constituents from debris surfaces and surface pore spaces or to remove contaminated debris surface layers.

5.4.1.7 Acid Washing

This chemical extraction technology is the same as water washing, except that an acid or acidic solution is used to remove hazardous constituents.

5.4.2 Performance Standards for Decontamination

5.4.2.1 Physical Extraction Technologies

For these technologies, performance standards are based on removal of the contaminated layer of the debris. Any contaminant subject to treatment may be treated by these technologies because the contaminants are removed as residue subject to the LDR treatment standards for the waste contaminating the debris.

Metal objects are to be treated to produce a "clean debris surface" by removing foreign matter adhering to the metal. A clean debris surface is defined as a surface that, when viewed without magnification, shall be free of all visible contaminated soil and hazardous waste, except that residual staining caused by soil and waste (e.g., light shadows, slight streaks, and minor discolorations), and soil and waste in cracks, crevices, and pits may be present provided that it does not exceed 5 percent of each square inch of surface area.

The performance standard for brick, cloth, concrete, paper, rock, pavement, and wood requires removal of at least 0.6 cm (1/4 inch) of the surface layer and treatment to a "clean debris surface."

The performance standard for glass, rubber, and plastic is the same as for brick, concrete, etc., except that removal of at least 0.6 cm of the surface layer is not required.

5.4.2.2 Chemical Extraction Technologies

The performance standards for these technologies are based on dissolution of the contaminants into the cleaning solution. Removal of the outer debris layer is not intended.

For water washing and spraying, the performance standard is treatment to a "clean debris surface". In addition, for porous debris, the thickness of each piece of debris may not be more than 1.2 cm (1/2 inch), and the contaminants must be soluble to at least 5 percent by weight in the decontamination solution.

For liquid-phase solvent extraction, the performance standard is the same as for water washing and spraying.

5.5

WASTE MATERIAL CLASSIFICATION

The wastes generated during this project will be hazardous or nonhazardous (residual) wastes. All waste and other material transported off site for disposal shall be inventoried, sampled, analyzed, and classified to determine whether it is hazardous or residual waste. If hazardous, the classification will also determine whether Land Disposal Restrictions (LDRs) contained in 40 CFR Part 268 will be met. If residual, the classification will also determine the class of residual waste landfill appropriate for disposal.

The intent of the project is to minimize the quantity of waste disposal off site. If on site disposal is limited, it is preferred that residual waste be shipped off site and hazardous waste remain on site. General waste management scenarios can be summarized as follows.

- At the completion of the project, waste excavated from the Conveyance will remain within a portion of the Conveyance under a capped portion.
- Material excavated from outside the Conveyance that is to be deposited within the Conveyance must be inventoried, sampled, analyzed, and classified as a hazardous or residual waste prior to such deposition. No hazardous waste from outside the Conveyance will be deposited in the Conveyance. Residual waste deposited within the Conveyance must be covered by the RCRA cap.

The Specification for Waste Materials Management is provided in Appendix 5.2. This specification defines criteria and requirements for sampling, evaluation, classification, storage, handling, management, and disposal of waste materials and decontamination residues that may be generated during this project.

5.5.1 Hazardous Wastes

5.5.1.1 **Soft Sediment, Underlying Sediment, and Soil Contaminated with Soft Sediment**

Soft sediment, soil, and other hazardous waste impacted materials that are excavated from the existing Conveyance are listed hazardous wastes with the RCRA waste codes F037 and/or F038 (40 CFR 261.31; 25 Pa. Code 261.31). These materials may also exhibit the toxicity characteristic (40 CFR 261.24; 25 Pa. Code 261.24). They are not expected to exhibit the hazardous waste characteristics of ignitability, corrosivity, or reactivity (40 CFR 261.21 through 261.23; 25 Pa. Code 261.21 through 261.23) based on previous testing and knowledge of the wastes.

5.5.1.2 Material Excavated from Outside of Conveyance

This material is not expected to be a hazardous waste, but is expected to be nonhazardous (residual) waste (see Section 5.5.2). These materials will be tested to confirm this assumption.

5.5.1.3 Other Listed Wastes

Decontamination solutions (if generated) meeting the RCRA definitions for listed solvent wastes (F001 through F005 as described in 40 CFR 261.31 and 25 Pa. Code 261.31) are the only other waste listings that may be applicable. If organic solvents meeting the RCRA listing criteria are generated, they will be classified as listed hazardous wastes. None of the other potential decontamination solutions would fit any listing description.

5.5.1.4 Other Characteristic Wastes

Decontamination solutions (if generated) would need to be tested to determine whether they exhibit the hazardous waste characteristics of ignitability (40 CFR 261.21; 25 Pa. Code 261.21), corrosivity (40 CFR 261.22; 25 Pa. Code 261.22), or toxicity (40 CFR 261.24; 25 Pa. Code 261.24) unless this determination can be made based on knowledge of the decontamination solution. Ignitable wastes are those liquids that have a flash point greater than 140°F (60°C). Corrosive wastes are those liquids that have a pH less than or equal to 2.0 or greater than or equal to 12.5. These solutions would not be expected to be reactive (40 CFR 261.23; 25 Pa. Code 261.23).

5.5.1.5 Hazardous Debris

Debris that is contaminated with hazardous waste and intended for offsite disposal must be managed as a hazardous waste or decontaminated and handled as a nonhazardous (residual) waste. Hazardous debris would be encountered only in the Conveyance. No hazardous debris will be excavated from outside the Conveyance and deposited within the Conveyance. Debris from outside the Conveyance is not expected to be hazardous.

5.5.1.6 Waste and Material Testing Requirements

Generators of waste must determine whether the waste is listed as a hazardous waste in Subpart D of 40 CFR 261 and Subchapter D of 25 Pa. Code 261. If the waste is not listed, the waste must be tested to determine whether it exhibits a characteristic of hazardous waste (Subpart C of 40 CFR 261 and Subchapter C of 25 Pa. Code 261). Hazardous waste generators must also test the waste, or an extract of the waste, to determine

whether the waste is restricted from land disposal (40 CFR 268.7). If a waste is restricted from land disposal, it must be treated to a level specified in the LDR regulations (40 CFR 268) by either the generator or the facility receiving the waste prior to land disposal.

5.5.1.7 Hazardous Waste Storage and Transport Requirements

Hazardous waste generator requirements are contained in 40 CFR 262 and 25 Pa. Code 262. These regulations require the use of manifests for offsite transport of hazardous wastes (40 CFR 262, Subpart B; 25 Pa. Code 262, Subchapter B) and also contain pre-transport requirements, such as labeling, marking, placarding, and accumulation time (40 CFR 262, Subpart C; 25 Pa. Code 262, Subchapter C).

In general, generators may store hazardous waste for up to 90 days without a permit. Waste can be stored in containers, tanks, and containment buildings in accordance with applicable hazardous waste regulations.

Offsite transportation of hazardous wastes will conform with 40 CFR 263 and 25 Pa. Code 263. Appropriately licensed transporters will be used for offsite transportation of hazardous waste. Offsite transportation includes transport on public roads and/or outside the refinery property lines.

5.5.2 Nonhazardous (Residual) Waste

Nonhazardous wastes generated in Pennsylvania are classified as residual wastes. Residual waste landfills in Pennsylvania are, in turn, divided into three general categories based on acceptable waste types for the particular class of landfill. Residual wastes will be categorized according to the type of residual waste landfill in which they may be disposed (in Pennsylvania). These categories are described below. This classification applies only to waste that is disposed of in Pennsylvania. Other states may have different requirements. Also, the landfill or disposal facility that receives the waste may have additional requirements. The Pennsylvania Department of Environmental Resources (PADER) must approve the disposal of each waste in each landfill located in Pennsylvania.

5.5.2.1 Class I Residual Waste Landfill

Class I landfills (which are equipped with double liner systems) may be used for disposal of all types of nonhazardous, industrial waste, including residual waste.

Residual wastes disposed of at a Class I, double-lined landfill must meet the following criteria (25 Pa. Code 288.423):

- Neither the residual waste nor leachate from the waste will adversely affect the ability of the liner system to prevent groundwater degradation.
- The residual waste will not react, combine, or otherwise interact with other waste that is or will be disposed of at the facility in a manner that will adversely affect the ability of the liner system to prevent groundwater degradation.
- The residual waste may not be bulk or noncontainized liquid waste. Containers holding free liquids may not be accepted unless the container is less than 1 gallon in size, except as otherwise provided in the facility's permit.
- The residual waste may not be allowed to react, combine, or otherwise interact with other waste or materials that results in generating extreme heat or pressure; fire or explosion; or toxic mists, fumes, dusts, or vapors. The potential for such interaction shall be determined using the procedures set forth in EPA-600/2-80-076 (A Method for Determining the Compatibility of Hazardous Wastes).

Hazardous wastes may not be disposed of at a Class I residual waste landfill, unless approved by PADER.

5.5.2.2 Class II Residual Waste Landfill

Residual wastes disposed of at a Class II (single-lined) residual waste landfill must meet the following criteria (25 Pa. Code 288.523):

- The residual waste may not be a type from which the maximum concentration obtained for a contaminant, based on a chemical analysis of its leachate, exceeds 50 times the groundwater parameter (e.g., drinking water standard) for that contaminant.
- Neither residual waste nor leachate from the waste will adversely affect the ability of the liner system to prevent groundwater degradation.
- The residual waste will not react, combine, or otherwise interact with other waste that is or will be disposed at the facility in a manner that will adversely affect the ability of the liner system to prevent groundwater degradation.

- Residual waste may not be bulk or uncontainerized liquid waste. Containers holding free liquids may not be accepted unless the container is less than 1 gallon in size, except as otherwise provided in the facility's permit.
- The residual waste shall have a pH between 5.0 and 12.5 unless otherwise specified by PADER in the facility's permit. The pH may be adjusted to meet this requirement.
- The residual waste may not be allowed to react, combine, or otherwise interact with other waste or materials that result in generating extreme heat or pressure; fire or explosion; or toxic mists, fumes, dusts, or vapors. The potential for such interaction shall be determined using the procedures set forth in EPA-600/2-80-076 (A Method for Determining the Compatibility of Hazardous Wastes).

Hazardous waste may not be disposed of at a Class II landfill.

5.5.2.3 Class III Residual Waste Landfill

Residual waste disposed of at a Class III (unlined) landfill must meet the following criteria (25 Pa. Code 288.623):

- The residual waste may not be of a type from which the maximum concentration obtained for a contaminant, based on a chemical analysis of its leachate, exceeds the following:
 - For metals and other cations, 25 times the groundwater parameter for a contaminant.
 - For contaminants other than metals and cations, the groundwater parameter for a contaminant.
- The residual waste may not be a wastewater treatment sludge unless it has been stabilized or solidified.
- The type, volume, and concentration of constituents of residual waste shall indicate that the waste and its leachate are capable of being attenuated by the soil under the disposal area in a manner that will prevent groundwater degradation.
- The residual waste will not react, combine, or otherwise interact with other waste that is or will be disposed at the facility in a manner that

will adversely affect the ability of the attenuating soil to prevent groundwater degradation.

- The residual waste may not have a petroleum-based oil and grease content that exceeds 1 percent by dry weight.
- Residual waste may not be bulk or uncontainerized liquid waste. Containers holding free liquids may not be accepted unless the container is less than 1 gallon in size, except as otherwise provided in the facility's permit.
- The residual waste shall have a pH between 5.5 and 9.5, unless otherwise specified by PADER. The pH may be adjusted to meet this requirement.
- The residual waste may not be allowed to react, combine, or otherwise interact with other waste or materials that result in generating extreme heat or pressure; fire or explosion; or toxic mists, fumes, dusts, or vapors. The potential for such interaction shall be determined using the procedures set forth in EPA-600/2-80-076 (A Method for Determining the Compatibility of Hazardous Wastes).

Hazardous waste may not be disposed of at a Class III landfill.

5.5.2.4 Residual Waste and Material Testing Requirements

Residual waste is defined to include garbage, refuse, other discarded materials, or other waste resulting from industrial, mining, or agricultural operations, if it is not hazardous. The definition of waste in the Pennsylvania residual waste regulations includes any contaminated soil, contaminated water, or other residue from the dumping, deposition, spilling, or leaking of a material into the environment.

Generators of residual waste must perform a detailed analysis that fully characterizes the physical properties and chemical composition of each type of waste that is generated (25 Pa. Code 287.54). A determination of whether the waste is a hazardous waste shall also be made. This analysis and determination shall be provided to PADER and to each solid waste management facility that accepts or proposes to accept the waste.

5.5.2.5 Residual Waste Storage, Onsite Disposal, and Transport Requirements

According to Pennsylvania residual waste regulations in 25 Pa. Code 287.2(i), if residual waste is disposed, processed, or treated at a hazardous waste

management facility, it shall be managed as a hazardous waste under hazardous waste regulations rather than as a residual waste.

A residual waste disposal permit is not required for the use of clean fill of the following materials, if they are separate from other waste and are uncontaminated: soil, rock, stone, gravel, brick and block, concrete, and used asphalt.

Residual waste may be stored on a temporary basis, not to exceed 1 year. Storage that exceeds 1 year is considered to be disposal, unless a longer time frame is approved by PADER. Surface water run-on and runoff is required to be minimized. A liner is not required, unless there is a potential for groundwater degradation (i.e., the seasonal high water table is at least 4 feet deep). For storage piles, wind dispersal shall be prevented. Temporary residual waste storage piles will be bermed to control runoff and prevent run-on (25 Pa. Code 299).

Onsite disposal of residual waste (outside of the Conveyance) would require a permit. As an alternative to a disposal permit, PADER can issue general permits for beneficial use of residual waste (25 Pa. Code 287.611 through 287.652). A permit application for such disposal is required. Beneficial use is defined as a method of processing or disposing of waste. PADER will not issue a general permit for (1) a residual waste landfill, (2) a valley fill or other fill, or (3) the use of residual waste to level an area or bring an area to grade, where the construction activity is not completed promptly after placement of the waste. However, a general permit may be issued for the beneficial use of waste as a construction material. This includes the use of residual waste as a road bed material, for pipe bedding, and similar operations. For beneficial use where the waste is placed directly on land, the waste must meet the minimum requirements for Class III landfill wastes. If a beneficial use permit is granted, PADER will also determine that the material is no longer a waste.

Manifests are not required for the transportation of residual waste. Residual waste transportation requirements are contained in 25 Pa. Code 299, Subchapter B.

Solid residual wastes will be completely covered during transportation, including parking, unless the waste cannot be dispersed. Residual wastes designated for offsite transport may not be mixed with hazardous wastes or other types of waste that create a risk of fire, explosion, or accumulation of harmful vapors or gases.

5.6 POLLUTION PREVENTION DURING EXCAVATION AND MATERIAL HANDLING

Material handling and transportation equipment and procedures will be conducted to preclude cross-contamination between hazardous waste, residual waste, and uncontaminated areas. Material decontamination, transfer, and loading points will be equipped with containment berms, drip pads, and/or liners to prevent releases to areas outside of the existing Conveyance.

5.6.1 Excavation at Zone A

Excavation and capping north of the 48" RCP (Zone A) will be performed sequentially in two subzones within Zone A. A description of the basic approach to one subzone is presented and is indicative of the method which will be used in both subzones. The subzones will be established as follows:

- A-1 - from the V-notch weir at the head of upper Walkers Run to the culvert at Hewes Avenue where the channel crosses beneath the road.
- A-2 - from the culvert east of Hewes Avenue to the 48" RCP.

The work in Zone A will progress from north to south in the direction of flow.

5.6.1.1 Area Preparation

Each subzone will be designated as an exclusion zone. Two designated areas for haul truck loading and decontamination will be constructed, one on each side of Hewes Avenue at the base and south of the railroad overpass structure.

Basic construction of the decontamination pads will consist of subgrade preparation and placement of a geotextile protective layer with a final 60 mil HDPE or Bentomat liner. Wooden mats will be placed on the liner for protection from truck traffic. The area will be surrounded by a runoff control berm, with a natural slope and open end draining into Walkers Run.

As part of the area preparation, water control pumps and dams will be provided at the head of upper Walkers Run to permit diversion of flow around Zone A-1 to the culvert at Hewes Avenue. In addition, a silt dam will be constructed in the vicinity of the 48" RCP inlet.

5.6.1.2 Demolition of Facilities

Once preparation is complete, demolition of the specified facilities will be performed by manual operations where access is limited and utilizing small excavation equipment where possible. Materials removed during these operations will be transported to a segregated area of the pH Basin.

5.6.1.3 Removal of Sludges and Excavation of Sediments

Loose sludges will be removed by vacuum truck where practical. Sludges will be pulled into the vacuum truck by manual labor using duckbill devices. Sludges will be transported in the vacuum truck to the pH Basin.

For sediment excavation in Subzone A-1, a small, rubber-tired backhoe/loader will be used. The loader will access the sediments from the west side of the channel and transport the material to leakproof trucks or sealed roll-off containers at the west Hewes Avenue loading station. This material will be transported to the pH Basin.

Subzone A-2 is for the most part inaccessible to large equipment. Sediment removal will be primarily by manual labor. For larger, more stable aggregates and soils, labor forces will use wheelbarrows and/or skid-mounted containers pulled to the east side loading station by double drum winch. Finer materials will be excavated by using high-pressure water lances, with downstream siltation control devices such as silt dams, hay bales, and filter fabric fences provided for capture of the removed sediments. The waste material will be excavated from the silt dam areas by hand. It will be placed into skid-mounted containers and winched to the east side loading areas at Hewes Avenue or loaded at the 48" culvert location using a long-reach excavator.

5.6.1.4 Decontamination of Structures

Decontamination work will progress from upstream to downstream. Rinse waters will be contained within the Conveyance channel. Solids will be captured downstream at the end of Zone A at hay bales, silt dams, or filter fabric fences.

For visibly contaminated concrete surfaces in Zone A, pressure washing procedures will be applied to achieve a decontaminated surface condition. Piping and other smooth surfaces will be washed with a caustic degreaser and will be rinsed with a pressure washer to achieve a decontaminated surface condition.

5.6.2 Excavation Within Sheetpile

The following major topics are addressed in the sections that follow:

- General description of site preparation activities
- pH Basin preparation
- Materials management
- Excavation

5.6.2.1 General Site Preparation Activities

Prior to excavation within the sheetpile, the pH Basin area will be prepared to receive the excavated materials. Other locations immediately adjacent to the Conveyance trench, but outside of the sheetpile, will be designated for storage of excavated material that is suitable for re-use under the cap or as subgrade backfill beneath the concrete Conveyance trench bottom. These materials will be stockpiled on top of a membrane liner and on a gradient that slopes toward the creek. Visquene will be used to protect the stockpiles from rain, and runoff control berms will be placed around the stockpile perimeter. If these materials are hazardous, they will be stockpiled within the boundary of the existing Conveyance.

Clean residual materials excavated from within the sheetpile, but which are not required in the existing Conveyance trench, will be segregated and stockpiled for future use on site after laboratory testing.

5.6.2.2 pH Basin Operation

The general construction sequence and operation of the pH Basin area will be as follows:

- Access Road and Truck/Equipment Decontamination Station Construction
- Facility Demolition/Decontamination
- Channel Relocation and Sheetpile Installation
- Sludge Placement and Pumping/Dewatering

Access Roads and Decontamination Station

Prior to initiating construction activities in the pH Basin area, access roads will be installed. The general procedure will be to scarify and recompact existing soils or place borrow material as a sub-base where necessary. A geotextile layer will then be placed over the sub-base with an additional 6-inch aggregate on top to serve as the final surface.

A decontamination area will be constructed for cleaning of haul trucks and equipment entering or leaving contaminated zones within the pH basin area. This area will also serve as a hot work zone for additional demolition work. Basic construction will consist of subgrade preparation and placement of a geotextile protective layer with a final 60 mil HDPE or geocomposite liner. Wooden mats will be placed on a liner for protection from equipment and truck traffic. The area will be surrounded by a runoff/runoff control berm. All water collected in this area will be discharged to the pH basin.

Existing Facility Decontamination/Demolition

The major facility removal will be the existing piping and instrumentation platform (pH Basin pier). Demolition will be accomplished by manual dismantling and removal of the structural steel by a crane. Work will progress from the outermost reaches of the pier toward the center. The larger steel sections will be placed in the decontamination/demolition area and will be further dismantled.

Underdrain Installation

An underdrain system will be placed in the pH Basin to remove water. The underdrain system will be capable of maintaining necessary freeboard.

Channel Relocation, Sheetpile Installation, and Sludge Removal

The pH Basin will be prepared to receive materials excavated to attain the required elevations and slopes at upstream locations during construction of the new channel as well as material from surge tank T-101. The preparation will include the following activities.

- Sheet piling will be installed just south of the railroad bridge and east of the dam at the downstream end of the pH Basin, both extending across the width of the conveyance. This will form the consolidation area boundaries at either end of the existing water course, and prevent upstream waters from entering the consolidation area.
- Sediments in the bottom of the pH Basin on the south side of the basin will be stabilized as required to provide a suitable subbase for the pipe installation described below.
- Two 60-inch-diameter corrugated metal pipes will be installed atop the solidified sediments on the bottom of the pH Basin, extending from the sheet pile at the railroad bridge to the existing overflow structure for

Tank T-101. The two pipes from the T-101 overflow structure will be extended to the sheet piling at the dam. This pipe will convey waters collected from the upstream side of the sheet pile wall at the railroad bridge to the pumps at the dam. An overflow weir will be installed in the T-101 overflow structure to direct normal flows to the dam face pumps, and allow storm flows to overflow to Tank T-101.

- Sediments existing in the consolidation area will be solidified and a portion of this material will be used to construct berms around the outside limits of the consolidation area. Drainage from this area will be conveyed to the plant treatment system.
- A dewatering system will be installed to remove liquids from the consolidation area and convey these liquids to the plant treatment system.

Sludge Placement in the pH Basin

Sludge to be placed in the pH Basin will come from Conveyance trench excavation of primary sludges and underlying contaminated sediments, as well as certain other miscellaneous sludges. A deliberate and continued effort will be made during Conveyance trench excavation to segregate materials which are suitable for re-use on site as either residual materials, or as stabilized subgrade backfill within the Conveyance trench, or for placement and stabilization underneath the cap.

Excavated material will be transported to the pH Basin via specialized, water-tight, sealed sludge containers. This material will be dumped into the pH Basin at a location away from the underdrain system to allow initial water separation. A low ground-pressure bulldozer will be used to continually move excavated materials out into the Basin from the point of delivery. As necessary, mats and a Gradall or a dragline will be brought to the pH Basin to further distribute sludges away from the point of discharge. The undercarriage and tailgates of delivery trucks will be cleaned with a high-pressure spray wash before returning to the Conveyance trench.

5.6.2.3 Spoil Materials Management

Excavated materials that come from the Conveyance trench will be re-used on site to the maximum extent possible. Three general types of spoil will result from Conveyance trench excavation between the sheetpile: primary sludges in the existing Conveyance, contaminated sediments in the existing Conveyance, and residual soils from trench sections that are not part of the existing Conveyance. The primary sludges and contaminated sediments are

destined for disposal within the Conveyance, in the pH Basin, or under the cap. The residual soils will be managed on site for re-use, following confirmatory analyses.

Residual soils will also be derived from other onsite excavations throughout the project. The majority of these soils will be re-used in the immediate area of excavation (i.e., trench backfill for piping excavations).

5.6.2.4 Excavation

Excavation between the sheetpile will proceed from upstream to downstream. Following sheetpile installation, a Gradall will place wooden equipment mats on top of the trench, across the tops of the sheetpile rows. Wet sludges and upper contaminated sediments will be excavated and loaded into sealed, water-tight boxes on roll-off trucks positioned at nearby access points. After loading, the roll-off box tops will be closed and the box, truck tires, and undercarriage will be cleaned with a high-pressure washer to prevent tracking of sludge out of the Conveyance area.

After removal of the uppermost contaminated materials, the Gradall will begin excavating more solid sediments. These sediments will almost certainly be saturated and will, therefore, continue to be loaded into sealed roll-offs. As the final excavation grade is reached, a pump will be placed in the excavation to control water infiltration during excavation.

The Gradall will track backwards on top of the mats, continuing to remove and load out waste materials from the trench. At the completion of each day's excavation operation, the decontamination technicians will take the spray wash wands into the trench to complete removal of waste materials from the inner sheetpile walls. A bobcat loader will also be working to the trench bottom to assist with gravel backfill placement and to clean up soils knocked loose from the sheetpile by the high-pressure washers.

Excavation within the sheetpiles will continue at a regular pace and will be limited only by the rate of sheetpile installation and storm events. After a rainstorm, the channel will be pumped out and excavation will continue. By excavating sediments from mats that are mounted on the sheetpile, equipment access will not be a problem, even immediately after stormwater is pumped from the trench.

During excavation, care will be taken to segregate materials that appear to be suitable for backfill under the cap. As stiff soils are excavated, these soils will be delivered to Conveyance trench areas where backfill is needed. Consistent

with the need for placement of sludges and less cohesive materials inside the pH Basin, excavation and transportation operations will be coordinated.

As necessary to conserve space inside the pH Basin, there may be stockpiling of the more cohesive trench sediments in areas immediately adjacent to the pH Basin. If these materials are hazardous, they will be stockpiled within the boundary of the existing pH Basin or Conveyance. Stockpiles would be underlaid with a suitable liner and surrounded by a runoff/runoff control berm. Waste materials may be covered with visquene. It would also be possible to establish a cement mixing operation in the pH Basin area to solidify trench spoil before placement and thus provide an opportunity to stockpile additional waste materials within the pH basin.